FIRST LESSONS

IN

PHYSIOLOGY AND HYGIENE.

For the Use of Schools.

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PREFACE

THE object of this book is to present concisely, clearly, and in logical order the most important elementary facts in Physiology and Hygiene. Sufficient anatomy has been given to render the physiology intelligible.

As far as possible, technical language has been avoided. The author has aimed to make each paragraph complete in itself, embracing a definite subject.

The "Syllabus" and "Questions for Review," it is believed, will be found useful not only in the regular course of instruction, but also for examination purposes.

C. K. M.

PHILADELPHIA, January, 1883.

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"The proper study of mankind is man."

POPE.

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FIRST LESSONS IN PHYSIOLOGY.

CHAPTER I.

INTRODUCTION.

1. Physiology.—The term *Physiology* is derived from Greek words which mean *a story about nature.* At first physiology included all kinds of natural study; but, as the word is now employed, it is the science which treats of the uses and actions of living objects. Human physiology is a study of what is done by and in the living human body. It is a study about ourselves, about the uses and actions of all parts of our bodies—head and trunk, hands and feet, brain and nerves, stomach, heart, and lungs. It teaches us about the movements of the body; about feeling, seeing, hearing, smelling, tasting, and thinking; about eating, breathing, keeping warm, growing, wasting, and dying. Animals and plants represent living nature. Minerals represent lifeless nature. Animals and plants are born, live, grow, and pass away according to certain laws, which differ from those regulating

the existence of minerals. They have parts with particular functions. *A function* is the special work which any part has to perform. Physiology is a study of these functions. Human physiology is a study of the functions of the human body.

2. Anatomy.—In order to understand physiology, we must have some knowledge of another science, called *Anatomy*, which may be defined as the study of the shapes of living things and of the parts of which they are made. The term *Anatomy* is made up from Greek words which mean *a cutting through;* and its real meaning is *dissection*, or the act of cutting an animal in pieces. Most of what is known about anatomy has been learned by dissection.

3. Hygiene.—When something has been learned of the formation of the body, and of its uses and actions, it is natural next to inquire how to care for it and keep it in health. We learn this by studying *Hygiene*, which is the science of health. The ancient Greeks believed in a goddess, or guardian angel, whom they called *Hygeia*, whose duty it was to watch over the health of the people. The term *Hygiene* is formed from the name of this goddess.

4. Tissues and Organs.—The word *tissue* means "that which is woven." The tissues of the body are its solid substances. These sometimes come together to form organs. *An organ* is a part of the body which has a special work or function. The body is made up of many tissues and organs. These tissues and organs are composed of minute bodies called *cells*. These

cells are too small to be seen with the naked eye, but they have been well studied with the microscope. It takes many thousands of them to occupy the space of a square inch. They may be roughly compared to minute bladders. Each cell has the power of taking from the blood what it needs to build up its own kind of tissue.

5. Divisions of the Body.—The body, for the sake of convenient study, may be divided into the *head*, *trunk*, *neck*, and *limbs*. The head includes all above the neck. The trunk is the solid, heavy portion between the neck and the legs. The neck is the narrow cylinder between the head and the trunk. Although a small, it is a most important region, for through it pass great nerves and vessels, and also tubes for the passage of air and food. The limbs are the two arms and the two legs, the upper and the lower extremities. Each upper extremity is divided into the *arm*, *forearm*, and *hand;* each lower extremity into the *thigh*, *leg*, and *foot.*

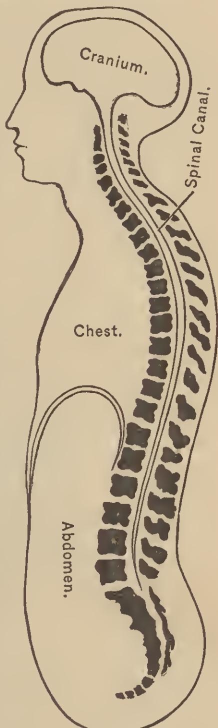


Fig. 1.
Cavities of the Body.

6. Cavities of the Body.—In the head and trunk are cavities containing important organs. The bones of the upper back part of the head form the cavity of the *skull*, or *cranium*, in

which is lodged the brain. This cavity opens by a hole in its lower part into a long, narrow *spinal canal*, which runs down through the *back-bone*, or *spinal column*, and contains the spinal cord. In the lower front portion of the head is the *cavity of the face*, into which the nose and mouth open. The front of the trunk is divided by a great partition, called the *diaphragm*, into two large cavities; the upper of these is the *chest*, the lower is the *abdomen*. The chief organs in the chest are the *heart* and *lungs*. In

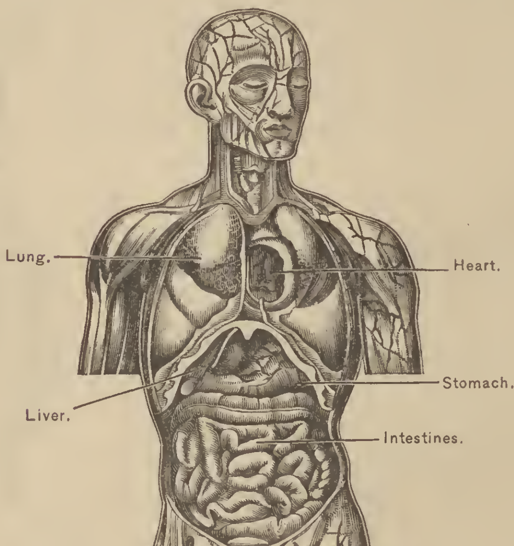


Fig. 2.—Organs of the Chest and Abdomen.

the abdomen are the *stomach*, *intestines*, *liver*, and other organs. The organs contained in the larger cavities of the body are called *viscera*. These larger

cavities are represented in Figure 1. Some of the organs of the chest and abdomen are represented in Figure 2.

7. Coverings of the Body.—The chief covering of the body is the *skin*. It is composed of two layers. The outer layer is very thin, and is called the *epidermis*, which means "upon the skin." It is so thin and fine that it is easily rubbed off. It washes off when we take a thorough bath. It is constantly being shed in powder or scales; but new epidermis forms as fast as the old disappears. In some places, as on the soles of the feet, the epidermis becomes very thick. It contains neither nerves nor blood-vessels; hence, cutting it does not cause pain nor draw blood. The lower layer of the skin is named the *dermis*, or *true skin*. It is well supplied with nerves and blood-vessels, so that cutting it causes pain and bleeding. The *nails* and *hair* are sometimes termed the *appendages* of the skin, that is, they are something added, but not absolutely necessary to the skin. The nails are epidermis which has become thick and horny. They are slowly but constantly growing. It has been calculated that a person dying in his eightieth year has changed his nails two hundred times at least. Nails grow by the addition of new matter to their under surface and roots. They protect the ends of the fingers and toes, and make the fingers more useful for seizing small objects. Even the hair, like the nails, is formed from the epidermis. The true skin sinks in, forming a depression, or hair sac, from which the hair grows.

8. The Lining Skin, or Mucous Membrane.—When it gets near the mouth, the skin changes color, and we have the *red lips.* Looking into the mouth and down the throat, a red, moist surface is seen; we have the "red lane" as it is sometimes pleasantly called. This red, moist lining of the mouth, throat, and canals and cavities beyond, is *mucous membrane.* Any thin skin or film is a membrane, and this mucous membrane is in reality a continuation of the outside skin, so that

> "There 's a skin without, and a skin within,
> A covering skin, and a lining skin;
> But the skin within is the skin without,
> Doubled inwards, and carried completely throughout."

The mucous membrane, or "lining skin," is moister and redder than the "covering skin," because its outer layer is much thinner than the epidermis, so that red blood-vessels shine through it. Moisture easily escapes from these vessels, and from *glands* which are found everywhere in the membrane.

9. Glands.—A *gland* is an organ which separates materials from the blood. The materials which are thus separated from the blood are called *secretions.* Glands of various sizes are found everywhere in the body. Sometimes glands are very simple in structure, consisting only of thin membranes and minute blood-vessels. Sometimes they are large and complicated organs.

10. Connective Tissue and Fat.—Widely diffused throughout the body is a substance called *connective tissue*, because it binds and connects together the

various organs. It is composed chiefly of whitish bands or cords. So completely does this tissue reach to all parts of the body, that if everything else could be dissected away, a model of the body, composed of it, would be left. In many places it takes the form of a loose web or network. Most of the fat of the body is lodged in the little spaces formed by this network. The organs are kept neatly in place, and the hollow and uneven places of the body are smoothed out by these two substances.

Syllabus.

The term Physiology is derived from Greek words which mean *a story about nature.*

Physiology is the science which treats of the uses and actions of living objects. Human physiology treats of what is done by and in a living human body.

Animals and plants have parts with particular duties or functions. Physiology is a study of these functions.

Anatomy is the study of the shapes of living things and of the parts of which they are made.

The term Anatomy is derived from Greek words which mean *a cutting through.*

Hygiene is the science of health. The word is derived from the name of the goddess *Hygeia*, who, according to the Greeks, watched over the health of the people.

A tissue means *that which is woven.* The tissues are the solid substances of the body.

An organ is a part of the body which has a special work or function.

The tissues and organs are composed of minute cells.

Each cell has the power of taking from the blood what it needs for its own tissue.

The body is divided into the head, trunk, neck, and limbs.

In the head and trunk are important cavities.

The cavity of the skull, or cranium, is formed by the bones of the upper back part of the head. In it is lodged the brain.

The spinal canal or cavity runs down through the backbone, or spinal column. It contains the spinal cord.

The cavity of the face is in the lower front portion of the head.

The diaphragm divides the trunk into.an upper cavity called the chest, and into a lower one known as the abdomen.

The chief organs in the chest are the heart and lungs.

The chief organs in the abdomen are the stomach, intestines, and liver.

The organs contained in the large cavities of the body are called viscera.

The chief covering of the body is the skin. It is composed of an outer thin layer called epidermis, which is constantly cast off and renewed, and of an inner thicker layer, the dermis, or true skin.

The epidermis contains neither nerves nor blood-vessels; the dermis or true skin is supplied with both.

The nails are epidermis which has become thick and horny. The hair is modified epidermis.

The red, moist lining of the mouth, throat, and parts beyond is mucous membrane. It is in reality a continuation or doubling inwards of the outside skin.

The outer layer of the mucous membrane is much thinner than the epidermis of the skin, so that blood-vessels shine through it, and moisture readily escapes from these vessels and from glands in the membrane.

A gland is an organ which separates materials called secretions, from the blood.

Connective tissue is diffused throughout the body, binding together its organs. Most of the fat of the body is lodged in the little spaces formed by a network of connective tissue.

Questions for Review.

What is the derivation of the term physiology?

What is physiology?

What is human physiology?

Mention some of the things studied in physiology.

What represent living and what lifeless nature?
How do animals and plants differ from minerals?
What is a function?
What does physiology study?
Define anatomy.
From what is the term anatomy derived?
What is the real meaning of the word anatomy?
Define hygiene. Give its derivation.
What does the word tissue mean?
What are the tissues of the body?
What is an organ?
What are cells? How large are they?
What power has each cell?
How can the body be conveniently divided?
Describe each of the divisions of the body.
How is each upper extremity divided?
How is each lower extremity divided?
How is the cavity of the skull, or cranium, formed?
What is lodged in the skull?
What is the spinal canal? What does it contain?
What is the cavity of the face?
How is the front of the trunk divided?
What are the chief organs in the chest?
What are the chief organs in the abdomen?
What are the viscera?
Of how many layers is the skin composed?
What is the epidermis?
Mention some facts about the epidermis.
What is the dermis? What does it contain?
What are the appendages of the skin?
What are the nails? How do nails grow?
What are some of the uses of the nails?
What is the hair? How does it grow?
What is the lining of the mouth, throat, and parts beyond called?
What is a membrane?
Of what is the mucous membrane a continuation?
Why is it moister and redder than the skin?
What is a gland? What are secretions?
What is connective tissue? Of what is it chiefly composed?
Where is most of the fat of the body lodged?

CHAPTER II.

THE BONES.

11. The Skeleton.—Every animal is formed after a certain pattern; it has a shape of its own, which depends mainly upon its frame-work of bone, or *skeleton*. The word skeleton means *a dried-up body*. As usually seen, it consists of bones which have been cleaned, dried, and put together with wires. In Fig. 3 a front view of the human skeleton is given. It is not an attractive picture, but in the living body its ugliness is hidden beneath coverings of skin, fat, and muscle.

12. Number of Bones in the Skeleton.—The skeleton contains about two hundred and eight bones, of which thirty are in the head, fifty-four in the trunk, and one hundred and twenty-four in the limbs. The number varies a little at different ages. Some of the bones which are separate in the infant or little child, grow together as age advances, and thus the bones become fewer in number.

13. Structure of Bone.—Bone is firm and dense outside, but it has canals and cavities within, which give it lightness as well as strength. The outer por-

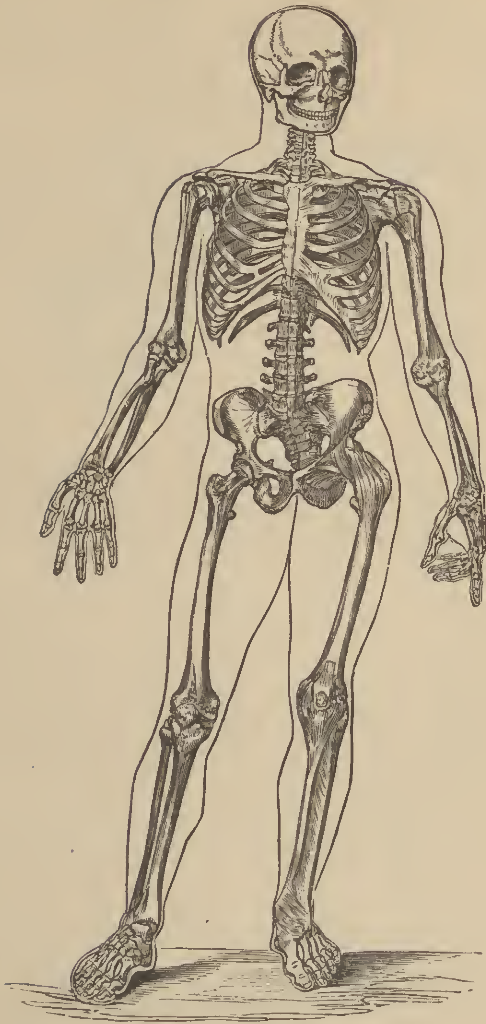


Fig. 3.—The Human Skeleton.

tion is sometimes called the *compact substance*, and the interior the *spongy substance*. They are both well

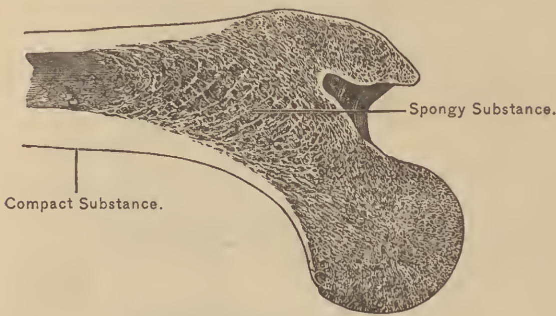


Fig. 4.—A Section of a Bone.

represented in Fig. 4, which is a view of a section of bone.

14. Composition of Bone.—Bones are composed of both animal and mineral matter. If about an ounce of muriatic acid is mixed with a pint of water, and a bone is placed in the mixture, in a day or two the mineral substance will be dissolved, leaving only the animal matter. The bone will still retain its form, but it will be so soft that it may be bent into different shapes, and, if a long bone, may even be tied into a knot. By putting the bone into an oven and carefully applying heat, the animal matter can be burned out. The shape is still retained, but the bone is now hard and brittle.

15. The Backbone.—The backbone, or spinal column (Fig. 5), supports and holds together the rest of the body. It is a strong bony column, reaching downwards from the skull, which is balanced on its summit.

It has four curves, two forwards and two backwards. It is not, as the name backbone would indicate, a single bone, but is composed of many bones or *vertebræ*. The word *vertebra* comes from the Latin, *vertere*, to "turn." One of these vertebræ is represented in Fig. 6. It has a heavy part in front, and at several points are projections or spines. By passing the hand up and down the back, some of these spines, which project backwards, can be felt through the skin. The different parts of a vertebra are so put together as to leave an open space near the centre. In the backbone, the vertebræ fit neatly one above the other, so that when all are in place, the holes or spaces come together and form a long tube, the *spinal canal*.

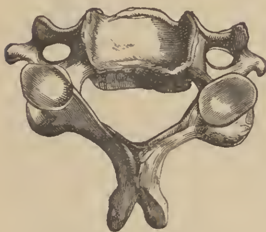


Fig. 6.—A Vertebra.

Fig. 5.
The Spinal Column.

16. General Facts about the Bones.—The only movable bone in the head (Fig. 7) is the *lower jawbone*, which works up and down when the mouth shuts and opens. The

bony chest is largely formed by long hoops of bone, called *ribs*, which run around from the backbone to the *breast-bone* in front. At the top and front of the chest on each side is a slender *collar-bone*, while at the top and behind is a broad, thin, three-sided *shoulder-blade.* In the lower part of the trunk is a basin or pelvis made up of several heavy bones. The bones of both the upper and lower limbs differ in size, but otherwise are similar. One long heavy bone is found in the upper arm and in the thigh, while the forearm and the leg below the knee contain each two bones. The wrist is composed of eight small bones, in two rows of four each. In the palm of the hand and in the fingers we have a series of slender bones parallel to each other. The bones of the upper extremity are shown in Figures 8, 9, and 10. The instep and heel are made up of seven bones. In the middle of the foot are five bones, so arranged with reference to the bones of the heel and the toes, as to give the foot the form of an arch. This arched form is represented in Fig. 11. This arching serves to break the force of falls and jars and to give spring to the step. In the toes, as in the fingers, a series of slender bones is

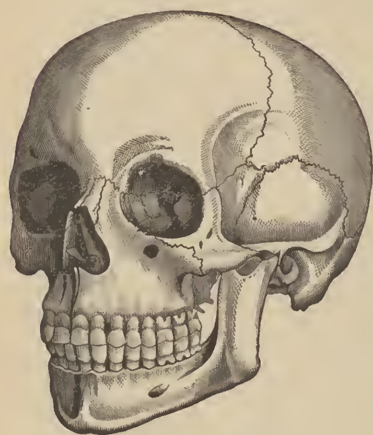


Fig. 7.—The Skull.

found. A small, thick bone, shaped somewhat like a

Fig. 8.
Bones of the Arm.

Fig. 9.
Bones of the Fore-arm.

Fig. 10.
Bones of the Wrist and Hand.

Fig. 11.—The Bones of the Foot.

chestnut, and called the *knee-pan*, passes over the knee-joint in front.

17. Movements of the Spine.—Although we have this long bony pillar up our backs, it is surprising how readily we can bend and turn and twist. It is also wonderful how perfectly this column bears the weight of the head and protects the contents of the skull and spinal canal from blows and shocks. One bone does not rest upon the other in the spinal column of the living person, but between the vertebræ are little cushions of gristle or cartilage, which help to prevent jarring in sudden movements of the body. In front, behind, between, and around the separate bones of the column are bands or ligaments, which hold the vertebræ together, and yet, being elastic, they stretch more or less, and thus permit considerable freedom of motion.

18. Movements of the Head.—The first two vertebræ at the top of the spine have peculiar shapes. In the middle of the first is a ring or hole. From the second a tooth or peg arises. This passes upwards through the hole in the first, and upon it the head turns and moves as upon a pivot. The first vertebra is called the *atlas*. According to an ancient fable the god Atlas carried the globe upon his shoulders, and hence the name atlas has been given to this bone which supports the globe-shaped head. The second bone is called the *axis*, an axis being the straight line or rod on which a revolving body turns.

19. Uses of the Bones.—The bones preserve the general shape of the body. As we have seen, the skeleton is the framework of the body. The soft parts cling to the supporting bones. The bones enable

us to stand erect and to perform the numerous movements of the body. They form grooves, canals, and cavities in which important organs are lodged and shielded. These bony passage-ways and compartments are beautifully adapted for the purposes of protection. The skull is arched or rounded, and will not break easily when struck, thus affording the best protection to the brain. The spinal column is strong and rugged, that it may play well its important part in guarding the delicate spinal cord and spinal nerves. The heart and lungs are free to move, and yet are well protected by the strong, elastic, bony chest.

20. One-Sided Development.—Most people are "right-handed." Children are usually taught to use the right hand in preference to the left. The wisdom of this instruction is doubtful. Every child should learn to use both hands. The bones of the right side of the body become larger than those of the left, because the limbs of the former are used so much more than those of the latter. We should, as far as possible, give both sides of the body, bones and everything else, an equal chance for development.

21. Diseases of the Bones.—In order that the bones shall be strong and healthy the animal and mineral matter which they contain must be in proper proportion. If they contain too much animal matter they will be too soft, and sometimes will actually bend out of shape. If they contain too much mineral matter they will be too brittle. The disease from which one suffers when the bones contain too much animal and too little mineral matter is called *rickets* or *rachitis*,

which term is derived from a Greek word meaning the "spine." The disease sometimes shows itself by some form of curvature of the spine; sometimes by bow-legs and badly-shaped arms and ribs. The best remedies for such a condition are life in the open air, plenty of nutritious food, cod-liver oil, and preparations containing lime.

22. Softness of the Bones in Early Life.—In infancy and childhood even healthy bones are much softer than in adult life, and they may be bent out of shape if they are used too soon or in an improper way. Some of the forms of spinal curvature are caused by children and young people holding their bodies too long in certain positions. Bending over too much when reading, writing, sewing, or doing similar work, will give the bones of the spine an unnatural twist. In youth the bones of the feet are sometimes pressed out of shape and position by tight shoes.

23. Brittleness of the Bones in Old Age.—In old age the mineral matter of the bones, which is chiefly a form of lime, becomes excessive. They lose much of their toughness and become brittle. Old people require to be more careful of their movements as they are in more danger of breaking their bones than the young. In some diseases a similar brittleness of the bones is produced by an excess of mineral substance.

24. Broken Bones.—When a bone is broken, and surgical help cannot at once be obtained, the whole limb should be carefully supported, and the patient kept perfectly quiet. When a broken limb is prop-

erly set it heals by a regular process. A soft substance is first thrown out between and around the ends of the fragments. This gradually, but very slowly, becomes harder and harder. If the bone is not kept at rest, the process of healing and hardening is interfered with, and hence surgeons use supporting splints, and require the limb to be kept at rest.

Syllabus.

Every animal has a shape of its own, which depends mainly upon its skeleton. The word skeleton means a dried-up body. As usually seen, it consists of bones which have been cleaned, dried, and put together with wires.

The skeleton contains about two hundred and eight bones, of which thirty are in the head, fifty-four in the trunk, and one hundred and twenty-four in the limbs.

Some of the bones which are separate in the infant, or little child, grow together as age advances.

Bone is firm and dense outside, but it has canals and cavities within, which give it lightness as well as strength.

Bones are composed of both animal and mineral matter. The mineral matter can be dissolved by muriatic acid; the animal matter can be burned out.

The backbone is a strong, bony column reaching downwards from the skull. It is composed of many little bones called vertebræ, which fit neatly one above the other.

When the vertebræ are all in place, holes or spaces in them come together so as to form a long tube,—the *spinal canal.*

The lower jaw-bone is the only movable bone in the head.

The bony chest is largely formed by ribs, which run around from the backbone to the breast-bone.

At the top and front of the chest, on each side, is a slender collarbone; at the top, behind, is a broad, thin, three-sided shoulder-blade.

In the lower part of the trunk is a basin, or pelvis, made up of several heavy bones.

One long heavy bone is found in the upper arm and in the thigh,

while the forearm and the leg below the knee contain each two bones.

The wrist is composed of eight small bones, in two rows of four each.

In the palm of the hand, and in the fingers, are a series of slender bones parallel to each other. Similar bones are found in the toes.

The instep and heel are made up of seven bones.

The bones in the middle of the foot are so arranged as to give the foot the form of an arch.

A small, thick bone, called the knee-pan, passes over the knee-joint in front.

Between the vertebræ are little cushions of gristle or cartilage, which help to prevent jarring in sudden movements of the body.

Elastic bands or ligaments hold the vertebræ together. They stretch more or less, and thus permit considerable freedom of movement.

In the middle of the first vertebra is a ring or hole. From the second a tooth or peg arises, and passes upward through the hole in the first. Upon this the head turns and moves, as upon a pivot.

The bones preserve the general shape of the body. The soft parts cling to them. They enable us to stand erect, and perform the numerous movements of the body. They form grooves, canals, and cavities for important organs.

We should, as far as possible, give both sides of the body, bones, and everything else, an equal chance for development.

If bones contain too much animal matter, they will be too soft; if they contain too much mineral matter, they will be too brittle.

The disease from which one suffers when the bones contain too much animal and too little mineral matter is called rickets.

Rickets shows itself by curvature of the spine; sometimes by bow-legs or badly-shaped arms and ribs. It should be treated with nutritious food, cod-liver oil, and preparations containing lime, and the patients should be kept in the open air as much as possible.

In early life even healthy bones are somewhat soft, and may be bent out of shape if they are used too soon or in an improper way.

In old age, and in some diseases, the mineral matter of bones becomes excessive. The bones lose much of their toughness, and become brittle.

Questions for Review.

Upon what does the shape of an animal mainly depend?
What is the meaning of the word skeleton?
As usually seen, of what does it consist?
How many bones does the skeleton contain?
How many bones in the head, in the trunk, and in the limbs?
Why does the number vary at different ages?
What is the structure of the outer portion of a bone?
What does a bone contain within?
What is the outer substance of bone called?
What name is applied to the inner substance?
Of what two kinds of matter is bone composed?
Describe an experiment for dissolving the mineral matter.
How can the animal matter be removed?
What purpose is served by the backbone?
Describe the backbone.
What are the vertebræ? Describe a vertebra.
How is the spinal canal formed?
What bone in the head is movable?
How is the bony chest formed?
Describe the situation of the collar-bone and shoulder-blade.
What is found in the lower part of the trunk?
How many bones are present in the arm, thigh, forearm, and leg?
Of how many bones is the wrist composed?
What bones are found in the hand and fingers?
How many bones are in the instep and heel?
How many bones are in the middle of the foot?
How are they arranged?
What bones are found in the toes?
What is the knee-pan?
What is present between the vertebræ?
How are the vertebræ held together?
Describe the first two vertebræ at the top of the spine.
What is the name of the first vertebra? Why was it so named?
What is the name of the second vertebra?
What was the origin of this name?
What are some of the uses of the bones?
What is the shape of the skull?

Why is the skull arched or rounded?

How is the spinal column built?

How are the heart and lungs protected?

Why do the bones of the right side become larger than those of the left?

How should the two sides of the body be developed?

What is necessary in order that the bones shall be strong and healthy?

What is rickets or rachitis?

How does the disease show itself?

What are the best remedies for rickets?

Why can even healthy bones be bent out of shape in early life?

Mention some of the ways in which deformity of the bones can be produced.

Why are the bones of the aged brittle?

Why should old people be careful of their movements?

What effect has certain diseases upon the bones?

CHAPTER III.

THE JOINTS.

25. A Joint.—A joint is the arrangement which is found where the ends of two or more bones come together. The ends of the bones are smooth and moist. This can be seen by looking at the knuckle of a leg of mutton before it is cooked.

26. The Joint Juice or Synovial Fluid.—The ends of the bones are coated with slippery gristle or cartilage, which is kept constantly wet by a thick, sticky fluid, which is sometimes called "joint juice," or "joint oil." It has, however, a higher-sounding name, *synovial fluid*, a term made up from Greek words which mean "like the white of an egg." It is poured out by a little sac or bladder which is placed between the ends of the bones. In this way the joint keeps itself well oiled.

27. Immovable Joints.—In the head, all the joints except those of the lower jaw are immovable. Most of the bones of the skull have saw-like edges, so that one dove-tails into another very firmly. Some of the

joints in the lower part of the trunk are also immovable. Some joints, as those of the spinal column, allow a little motion. Between the bones which form the immovable joints is a layer of tough tissue or membrane. When a bone is struck a hard blow the shock causes it to vibrate and sometimes to break. The tough membrane between the bones serves to deaden this shock and prevent breaking.

28. Movable Joints.—Movable joints are those which allow motion of one part of the body upon another. They differ according to the kind of motion which they permit. A *hinge-joint*, such as is found at the elbow, knee, or ankle allows a forward and backward movement, like that of a door on its hinges. Figure 12 represents the elbow-joint. A *ball-and-socket-joint* is one in which a rounded surface on the end of one bone moves in a cup in another. Joints of this sort are found at the shoulder and hip. A *pivot-joint* is formed by one bone, shaped like a peg or pivot, fitting into a hole in another bone. The best example of this is furnished by the two bones at the top of the spinal column.

Fig. 12.
The Elbow-Joint.

29. Ligaments of the Joints.—Bands or slips, called *ligaments*, from the Latin word *ligare*, "to bind," pass from one bone to the other at the joints. These ligaments prevent the bones from getting too far apart. They tie them together loosely, so that they can move upon each other to a certain extent. The sac or

bladder which secretes the "joint-juice," or synovial fluid, also acts as a ligament, one side of it being attached around the end of one bone, and the other around the extremity of the opposite bone.

30. Pressure of the Air upon the Joints.—The air, although invisible, is a great force and is always exerting pressure. It is supposed that this pressure of the air assists the ligaments in keeping the bones

Fig. 13.—Section of the Hip-Joint.

in place at the joints. The thigh-bone at the hip-joint is certainly kept in position partly by the pressure of the atmosphere. Figure 13 represents a section of the hip-joint. The head of the thigh-bone fits very closely in the socket. The cavity of the joint is, moreover, completely closed by the synovial sac. If, while the bones are in position, a hole be bored

into the joint, so as to allow air to get into its cavity, the head of the thigh-bone will at once fall partly out of the socket, the pressure of the air now acting both from within and without.

31. Unusual Motion in Joints.—Some people have great freedom of motion in their joints. They can, for instance, bend their hands backwards, and their fingers backwards and sidewise. They are probably able to do this because the joint-ligaments are longer than usual, and hence allow more separation of the ends of the bones. Children for sport sometimes pull their fingers to "make their joints crack." This is a dangerous habit, for by so doing they may overstretch the ligaments of the joints, and cause an injury which it will be hard to remedy.

32. Uses of the Joints.—Without our numerous movable joints we would be stiff and awkward creatures. The useful and graceful movements which we can now make would be impossible. The joints are so arranged as to allow each movable part of the body to perform its movements to the best advantage. At the elbow a forward and backward movement of the forearm upon the arm is all that is permitted by the hinge-joint, but this is all that is required to make the arm most useful. The cup of the ball-and-socket-joint at the shoulder is shallow, and movements of the arm can be made in almost any direction. The socket of the hip-joint is deep, an arrangement which allows less freedom of motion, but gives greater firmness and security. The pivot-joint of the spinal column is supplied with ligaments which permit the head to move

from side to side, but not far enough in any direction to damage the delicate nervous matter within the skull and spine. The superiority of man over other animals is largely due to the number and the perfection of the movements which can be performed by the hand and fingers; and these movements are made possible by numerous joints.

33. Injuries of the Joints.—Sudden jars, falls, or blows may wrench a joint or put it out of place. The violent twisting and tearing of the ligaments and soft parts about a joint is called a *sprain*. A joint is put out of place, or *dislocated*, when the ends of the bones, which naturally work upon each other, are forced apart. Sometimes in ball-and-socket-joints the smooth round head of the bone is pulled entirely out of the socket in which it should always play. Remembering these facts, children should not be too rough in their sports. Injured joints should be promptly attended to or permanent mischief may result. Dislocations should be set as soon as possible.

Syllabus.

A joint is the arrangement found where the ends of two or more bones come together. The ends of the bones are smooth and moist.

The ends of the bones are coated with slippery gristle, which is kept constantly wet by the joint-juice, or synovial fluid.

The synovial fluid is poured out by a little sac or bladder, which is placed between the ends of the bones.

In the head, all the joints except those of the lower jaw are immovable.

Some of the joints in the lower part of the trunk are also immovable.

Some joints, as those of the spinal column, allow a little motion.

A tough membrane between the bones which form the immovable joints serves to deaden the shock given to bones when they are struck.

Movable joints are those which allow motion. They differ according to the kind of motion which they permit.

A hinge-joint, such as is found at the elbow, knee, or ankle, allows a forward and backward movement.

A ball-and-socket-joint is one in which a rounded surface moves in a cup. Such joints are found at the shoulder and hip.

A pivot-joint, of which the best example is found at the top of the spinal column, is formed by a peg of bone, fitting into a hole in another bone.

Ligaments pass from one bone to the other at the joints, and prevent the bones from getting too far apart.

The sac which secretes the joint-juice acts also as a ligament.

The pressure of the air assists the ligaments in keeping the bones in place.

The thigh-bone at the hip-joint is certainly kept in position partly by the pressure of the atmosphere.

If air is allowed to get into the cavity of the hip-joint, the head of the thigh-bone will at once fall partly out of its socket.

Some people have great freedom of motion in their joints; because the joint-ligaments are longer than usual.

Pulling the fingers to "make the joints crack" is a dangerous habit, which may cause overstretching of the ligaments of the joints.

A joint is so arranged as to allow each movable part to perform its movements to the best advantage.

At the elbow a forward and backward movement is that which is most required and allowed.

At the shoulder the cup of the ball-and-socket-joint is shallow to allow of movements in many directions; at the hip it is deep to give greater firmness and security where these qualities are needed.

The pivot-joint of the spinal column is supplied with strong ligaments, which permit the head to move just as far as it is safe for it to go.

The superiority of man over other animals is largely due to his numerous joints.

Sudden jars, falls or blows may cause sprains or dislocations.

Injured joints should be promptly treated.

Questions for Review.

What is a joint?

With what are the ends of the bones coated?

How are they kept moist?

What is the scientific name of the joint-juice?

From what is the term "synovial" derived?

By what is the synovial fluid secreted?

What are the only movable joints of the head?

How are most of the bones of the skull united?

Where, besides in the head, are immovable joints found?

How much motion do the joints of the spinal column allow?

What is present between the bones which form the immovable joints?

What is the effect of striking a bone a hard blow?

What purpose does the tough membrane between the bones serve?

What are movable joints? How do they differ?

What is a hinge-joint? Where are hinge-joints found?

What is a ball-and-socket-joint? What joints are of this kind?

What is a pivot-joint? What is the best example of a pivot-joint?

What are the ligaments of the joints?

From what is the word ligament derived?

How do the ligaments of the joints act?

How does the sac or bladder which secretes the joint-juice act?

What assists the ligaments in keeping the bones in place?

How does the head of the thigh-bone fit in its socket?

How is the cavity of the hip-joint closed?

How can it be proved by experiment that the pressure of the air helps to keep the hip-joint in place?

Why have some people greater freedom of motion in their joints than others?

What dangerous habit have some children? Why?

How are the joints arranged with reference to movements?

What movement is permitted at the elbow?

Why is the socket at the shoulder-joint shallow?

Why is the socket of the hip-joint deep?

How is the pivot-joint in the neck strengthened?

To what is the superiority of man over other animals largely due?

What is a sprain? What is a dislocation?

Why should injured joints be attended to promptly?

CHAPTER IV.

MUSCLES AND MOVEMENTS.

34. Motion.—Motion exists everywhere. Every living animal is in some way blessed with motion. Sometimes a little motion is all that tells us that an animal is alive. We can study the forms of motion in animals in different ways. Sometimes the study is about the movement of the whole animal from place to place, as of a man walking, a fish swimming, or a bird flying; this we call *locomotion.* Sometimes it is about the movement of a part of the animal, as of a limb in striking or kicking, or of the eye when it turns from side to side. Sometimes it is about the movements of fluids or gases, as of blood in the vessels, and of the air in the lungs.

35. The Machinery of the Body.—The body may be compared to a machine. Some machines are simple, both as regards the manner in which they are made and the work they have to do; others are complex, have more parts, and serve more purposes. The human body resembles the latter class. Mechanics is the science of machinery, and in studying the body

we are, therefore, learning lessons in animal mechanics. The limbs have their levers and cords; the jaw moves up and down on its hinges; the blood is distributed by its pump and pipes; the lungs act as bellows, drawing in and forcing out air; the food is pushed onward by the movement of the food-canal. For eating, drinking, seeing, hearing, thinking, and all other functions, a special machinery is provided. All these functions in some way involve motion.

36. Movements of the Limbs.—We shall study in this Chapter chiefly about the machinery and movements of the limbs. Compared with some of the fine changes which are going on in the hidden places of the body, these movements are coarse and rough; and yet they are wonderful when deeply studied. The movements of our limbs are directly brought about by the help of bones and joints, which have just been considered, and of the muscles, which we shall now study. The bones, and everything which clings to them, are moved by the muscles. The joints permit this motion. The muscles are the motors, or movers; in some way they do the pulling and pushing which cause the motion.

37. Muscle and the Muscles of the Body.—*Muscle* is the flesh or lean meat. When we eat lean beefsteak or mutton we are eating muscle. It comprises a large part of the human body. It is arranged in many different masses or bundles, which form the *muscles*, of which the body contains more than five hundred. Fig. 14 exhibits the principal muscles of the front of the body.

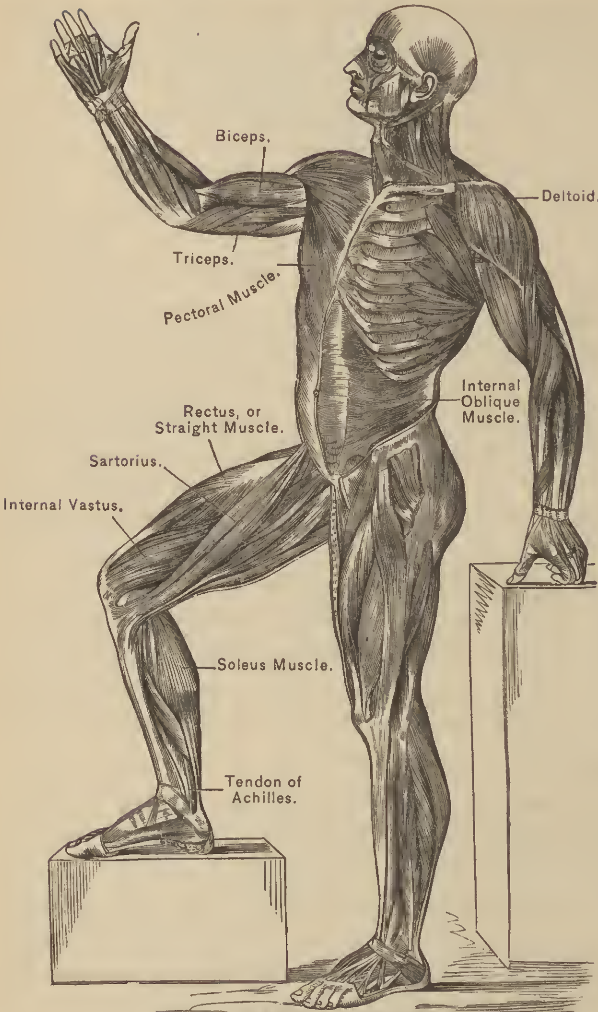


Fig. 14.—Principal Muscles of the Front of the Body.

38. The Names of the Muscles.—Each muscle has its own name, which has been given to it because of something peculiar in its shape, size, or appearance. The *pectoral* muscle is the muscle of the breast or chest, *pectus* being the Latin for "breast" or "chest." *Biceps* means "two-headed," and *triceps*, "three-headed," the first of these muscles beginning in two parts and the second in three. The large, thick muscle covering the shoulder-joint is called the *deltoid*, because of its likeness to the Greek letter Δ (*delta*). The *oblique* muscles have their fibres running in a slanting direction; while the fibres of the *recti* or *straight* muscles run more directly. The meaning of the word *sartorius* is, "belonging to a tailor," and the muscle crossing the thigh, which is the longest in the body, is so named because a tailor uses it in crossing his legs. The *internal vastus* muscle is of "vast" size. The *soleus* muscle, forming part of the "*calf*" of the leg, is so termed from a supposed resemblance to the sole of a foot or shoe.

39. The Different Parts of a Muscle.—A muscle has a middle fleshy part, which is called the *body*, and two ends of tough, whitish material, called the *sinews* or *tendons*. Sometimes these tendons are short, sometimes they are long, sometimes they are round, sometimes flat. They are always strong.

40. The Tendon of Achilles.—The strongest tendon of the body is the *tendon of Achilles* (as shown in Fig. 11, page 25, and Fig. 14, page 42), which runs from the muscles of the calf to the heel. This tendon received its name in a curious way. The story is that

Achilles, a famous Greek hero, when a babe, was dipped by his mother into the river Styx, the waters of which rendered the body invulncrable. When the dipping took place the child was held by the heel. Achilles passed unharmed through many wars, but finally came to his death from an arrow-wound in the heel. Anatomists, therefore, have called this tendon of the heel the tendon of Achilles.

41. The Structure of Muscle.—The body, or fleshy part, of the muscle is made up of a large number of strings or fibres of flesh, running in the same direction. These are held together by a web of connective tissue, and they are arranged in bundles of different sizes, as shown in Fig. 15.

Fig. 15.—Muscle slightly Magnified.

42. Contraction of Muscles.—All muscle can contract or shorten itself. As muscles contract they become thicker; they spread out sidewise. Contractility belongs to muscle; it is one of its properties. Muscles can be made to contract in various ways, for instance, by applying to them a current of electricity. When the arm, leg, hand, foot, mouth or eyelid, or any other part, is moved, it is through a muscular contraction.

43. The Biceps Muscle.—Let us select one muscle and study its actions. When the forearm is bent, in bringing the hand up towards the shoulder, a distinct bulging occurs between the elbow and the shoulder. This is caused by the contraction of the large muscle on the front of the arm, called the *biceps*. Two cords

go up from the body of the muscle to points above. A single cord goes to one of the bones of the forearm. The forearm can move freely on the arm at the elbow-joint, both of its bones moving together. The contraction or shortening of the biceps muscle must therefore pull the forearm up towards the arm, giving an illustration of the *lever*.

44. Levers.—It may help us to understand better the movements of the limbs if we recall here a few facts about levers. A lever is simply a lifter or raiser. To carry out the act of lifting or raising, *power* must be used upon a *weight;* and the lever must have a place to rest, and a point called a *prop* or *fulcrum*, about which it can move. Levers are of three orders. In the first order the fulcrum is between the power,

Fig. 16.—Lever of the First Order.

Fig. 17.—Lever of the Second Order.

and the weight (Fig. 16). A crowbar applied to lift a stone is a lever of this kind. In the second, the weight is between the power and the fulcrum (Fig. 17). An oar is a lever of this sort. In the third, the power acts between the fulcrum and the weight (Fig. 18). The boy fishing with a long rod often makes it a lever

Fig. 18.
Lever of the Third Order.

of this kind. He rests one end of the rod on the ground and thus gets his *fulcrum;* then, supporting it with one hand he applies his *power* with the other, and swings around the *weight*, which is made up of rod, line, and fish.

45. Levers of the Third Order in the Limbs.—In our limbs we have chiefly levers of the third order. Such a lever is beautifully illustrated in the movement of the forearm as shown in Fig. 19. The ful-

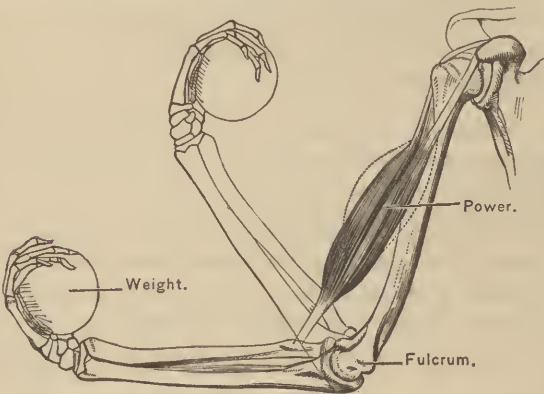


Fig. 19.—Lever of the Third Order in the Limbs.

crum is at the elbow; the weight is made up of the weight of the bones of the forearm and hand and the ball which is grasped by the latter; the power is in the *biceps* or flexor muscle, and is applied where its lower end is fastened to one of the bones of the forearm, and therefore between the fulcrum and the weight.

46. Action of the Muscles in General.—Just as the biceps muscle has the power of contracting, so muscles everywhere have the power of contracting and producing movement. In contracting they act on the bones as on levers. Some organs, as the heart and blood-vessels, simply squeeze together as they contract.

Syllabus.

Motion exists everywhere.

Locomotion is movement from place to place, as of a man walking, a fish swimming, or a bird flying.

The body may be compared to a complex machine.

Mechanics is the science of machinery, and in studying the body we are learning lessons in animal mechanics.

For all the functions of the body a special machinery is provided.

The movements of our limbs are directly brought about by the help of bones, joints, and muscles.

The muscles are the motors or movers.

Muscle is the flesh or lean meat.

Muscle is arranged in masses or bundles, which form the muscles, of which the body contains more than five hundred.

The pectoral muscle is the muscle of the breast or chest.

Biceps means "two-headed," and triceps "three-headed," the first of these muscles beginning in two parts and the second in three.

The deltoid muscle is so called because of its likeness to the Greek letter Δ (*delta*).

The fibres of the oblique muscles are slanting, those of the recti or straight muscles are straight.

Sartorius means "belonging to a tailor." A tailor uses the sartorius muscle in crossing his legs.

The internal vastus muscle is of vast size.

The soleus muscle is so termed from a supposed resemblance to the sole of a foot or shoe.

A muscle has a middle fleshy part called the body, and two ends of tough, whitish material, called sinews or tendons.

The strongest tendon of the body is the tendon of Achilles, which runs from the muscles of the calf to the heel. This tendon received its name from Achilles, a famous Greek hero.

The body of a muscle is made up of a large number of fibres of flesh running in the same direction. These are arranged in bundles of different sizes.

Contractility is one of the properties of muscle. When a part of the body is moved it is through a muscular contraction.

The forearm is bent on the arm by the contraction of the biceps muscle on the front of the arm.

The forearm moves freely on the arm at the elbow-joint, the contraction or shortening of the biceps pulling the forearm up towards the arm.

We have in the movement of the forearm on the arm an illustration of the lever or lifter.

Levers are of three orders. In the first the fulcrum is between the power and the weight; in the second, the weight is between the power and the fulcrum; in the third, the power acts between the fulcrum and the weight.

Our limbs chiefly contain levers of the third order.

In the movement of the forearm on the arm, the fulcrum is at the elbow; the weight is made up of the bones of the forearm and hand, and whatever is grasped by the latter; the power is in the biceps, and is applied where its lower end is fastened to one of the bones of the forearm, and therefore between the fulcrum and the weight.

Just as the biceps muscle has the power of contracting, so muscles everywhere have the power of contracting and producing movements.

In contracting, the muscles act on the bones as on levers.

Some organs, as the heart and blood-vessels, simply squeeze together as the muscles contract.

Questions for Review.

What is said about the existence of motion?

What alone sometimes tells us that an animal is alive?

What is locomotion? Give illustrations.

What movements of the parts of an animal do we study?

What movements of fluids and gases do we study?

To what may the body be compared?

What is mechanics? What is animal mechanics?

Give some illustrations of the machinery of the body.

What do all of the functions of the body involve?

How are the movements of the limbs brought about?

What do the muscles do?

What do the joints permit?

What are the muscles with reference to motion?

What is muscle?

How are the muscles formed?

How many muscles does the body contain?

How did many of the muscles receive their names?

Define and give the derivation of the words pectoral, biceps, triceps, deltoid, recti, sartorius, vastus, and soleus.

What are the different parts of a muscle?

Which is the strongest tendon of the body?

Relate the story about the way in which this tendon received its name.

Of what is the fleshy part of muscle composed?

How are the muscular fibres held together and arranged?

What property is possessed by all muscle?

As muscles contract, how do they change in shape?

Mention one way in which muscles can be made to contract.

Give illustrations of movements due to muscular contraction.

When the forearm is bent on the arm what occurs between the elbow and shoulder? What causes the bulging?

How is the biceps muscle attached above and below?

How does the forearm move on the arm?

Of what have we an illustration in this movement?

What is a lever? Levers are of how many orders?

Explain the three orders of levers.

Give an illustration of each order.

What kind of levers are chiefly found in the limbs?

In what movement is a lever of the third order beautifully illustrated?

In the movement of the forearm on the arm, where is the fulcrum?

What constitutes the weight?

Where is the power? How is it applied?

What power have all muscles?

In contracting, how do they act on the bones?

What is the result of the contraction of some organs, as the heart and blood-vessels?

CHAPTER V.

MUSCULAR EXERCISE.

47. Exercise.—Any kind of muscular movement is physical exercise. The term exercise, however, is usually applied to the practice of muscular movements under the control of the will, with the view of developing certain parts of the body. The health of the body depends largely upon the proper exercise of its different parts.

48. Muscular Exercise and Muscular Contractility.—The ability to perform the movements which constitute muscular exercise depends upon the property of contractility which belongs to muscle. The muscle shortens by virtue of its contractility; but the shortening cannot continue permanently. The muscle relaxes and lengthens again. Shortening and lengthening, or contraction and relaxation, follow each other, and thus the muscles are exercised. Just as muscular contraction may be weak or strong, slow or rapid, simple or complicated, so exercise may be greatly varied.

49. Effect of Exercise on Muscle.—If the muscles are exercised frequently; in other words, if they are made to contract again and again, they increase in size and strength. We see illustration of this fact in the strong right arm of the blacksmith, and in the stout back of the porter. If the muscles are not used frequently they become small and weak. This is seen in those who from choice or necessity do not lead physically active lives. In those who suffer from the disease called *paralysis* the muscles waste away.

50. Effect of Exercise on the Bones.—Strange as it may appear, the bones as well as the muscles may be changed in size and form by muscular exercise. The bones, particularly in early life, will yield in various ways to the force exerted by the muscles. Here and there on the bones are seen little elevations at points where the muscles are inserted. They have actually been pulled out little by little by the contractions of the muscles. Bones are sometimes given a twist because the muscles on one side are stronger than those on the opposite side. In time the whole bony framework can be strikingly changed by muscular exercise. If this exercise is properly regulated, the change will be beneficial.

51. Effect of Exercise on Various Tissues and Organs.—Besides muscle and bone, many tissues and organs can be favorably influenced by proper muscular exercise. As has already been shown, the tissues and organs are composed of innumerable minute bodies called cells, each of which has the power of taking from the blood what it needs to

build up its own kind of tissue. These cells are born, die, pass away, and are replaced by others. Exercise of any part hastens their decay and death, but, at the same time, it gives vigor to the process of repair. It calls blood to the part, and new material of the best quality takes the place of the worn-out particles. The tissue is thus constantly renewed. The body is kept fresh and new. While the flow of blood is quickened, the organs which pump and carry it are strengthened and improved. Breathing is largely performed by muscular action, and exercise causes the lungs thoroughly to expand and contract, and thus to get rid of impure air and replace it with that which is fresh and pure. When the brain, or thinking organ, is over-worked, muscular exercise relieves it by causing the blood to flow to other parts. Exercise brings sound sleep by causing a healthful fatigue and by calling away excitement from the brain. It gives a good appetite by creating a demand for food, and at the same time stimulating the organs which receive the food and prepare it for the blood. It keeps in healthy action the skin and other organs which carry off waste matter.

52. Results of Systematic Exercise.—All muscular regions of the body can be developed, and even the height can be increased, by systematic exercise. Under such exercise, directed by Maclaren, author of a book on *Physical Education*, a pupil sixteen years old, in one year grew from 5 feet 2¾ inches in height to 5 feet 4¾ inches, and in weight increased from 108 to 129 pounds. His girth of chest increased from 31

to 36 inches; his forearm from 8 to 10 inches, and his upper arm from $9\frac{1}{4}$ to $11\frac{1}{4}$ inches. Many remarkable accounts of the value of systematic exercise have been published. Bryant, the poet, who lived in the enjoyment of good health to the great age of eighty-four years, was in the habit of rising early every morning, and going through a series of exercises designed to expand the chest, and call into action all the muscles and articulations of the body. He also regularly walked to and from his place of business, a distance of several miles.

53. Deformities Prevented or Corrected by Exercise.—Certain deformities are either the direct result of insufficient exercise; or, they could by judicious exercise be largely remedied. Rounding or drooping shoulders, stooping, spinal curvature and a growing to one side, are among these deformities. Pigeon-breast, in which the breast-bone is too prominent, with flatness of the upper ribs; and hollow-chest, in which the breast-bone is sunk in, can both be much improved by proper exercise in youth.

54. Fitness, Variety, and Moderation in Exercise.—Exercise should be regulated by its special fitness for the individual. The work of the strong should not be given to the weak. Variety should not be overlooked. Such exercises in turn should be used as will tell favorably on all parts. Exercise should never be carried to the point of fatigue or exhaustion. It should be practised for health and not for strength alone. Strength will probably result from it, but this should not be the primary object.

55. Time for Exercise.—About midway between the hours for meals is generally the best time for active exercise. In exceptional instanccs, however, when the strength fails rapidly betwecn meals, vigorous exercise is bettcr undergonc in from one to two hours after taking food. Just before meal-time, when the stomach is empty, and the blood needs replenishing, much exertion may fatigue and depress the system. On the other hand, if the muscles be too actively exercised just after a meal the work of the stomach may be stopped or disturbed. Exercise in the early morning before breakfast, when the system has been refreshcd by sleep, agrees with some people, but not with all. The weak and delicate cannot stand it unless they have been gradually trained to it.

56. A Sound Mind in a Sound Body.—Children who attend to their plays, games, and exercises, will be better fitted for their indoor mental work. Books and studies must not be neglected in the hours appointed for them. The aim should be to train both mental and physical powers so as to insure a sound mind in a sound body.

Syllabus.

The term exercise usually is applied to the practice of muscular movements under the control of the will, with the view of developing certain parts of the body.

Muscular movements depend upon the property of contractility which belongs to muscle.

Muscles shorten and lengthen, or contract and relax, and thus are exercised.

Exercise, like muscular contractions, may be greatly varied.

If the muscles are exercised frequently, they increase in size and strength; if they are not used frequently, they become small and weak.

In those who suffer from paralysis the muscles waste away.

The bones can be changed in size and form by muscular exercise.

Here and there on bones are seen little elevations at the points where the muscles are inserted. They have been pulled out by the contractions of the muscles.

Bones are sometimes given a twist by overaction of the muscles of one side.

In time muscular exercise can change the whole bony framework. Proper exercise will change it for the better.

Besides muscle and bone, many tissues and organs can be favorably influenced by proper muscular exercise.

The tissues are composed of cells which are born, die, pass away, and are replaced by others.

Exercise hastens the decay and death of these cells, but, at the same time, it gives vigor to the process of repair. It calls new blood to a part, and renews the youth of the tissue.

While the flow of blood is quickened, the organs which pump and carry the blood, are also strengthened and improved.

Exercise causes the lungs thoroughly to expand and contract, and thus to get rid of impure air and replace it with that which is fresh and pure.

Muscular exercise relieves the brain by causing the blood to flow to other parts.

Exercise brings sound sleep, gives a better appetite, and keeps the skin and other organs which carry off waste in healthy action.

All muscular regions of the body can be developed, and even the height can be increased, by systematic exercise.

Certain deformities are either the direct result of insufficient exercise, or, at least, by judicious exercise can be largely remedied.

Rounding or drooping shoulders, stooping, spinal curvature, a growing to one side, pigeon-breast, and hollow-chest, are among these deformities.

Exercise should always be in fitness, variety, and moderation. It should be practised for health and not for strength alone.

About midway between the hours for meals is generally the best time for active exercise.

Exercise in the early morning before breakfast, when the system has been refreshed by sleep, agrees with some people, but not with all.

Children who attend to their plays, games, and exercises, will be better fitted for their indoor mental work. Books and studies must not be neglected.

Questions for Review.

What is physical exercise?

To what is the term exercise usually applied?

Upon what does the health of the body largely depend?

Upon what property does muscular exercise depend?

Explain how muscles are exercised by virtue of their contractility.

What effect has frequent exercise on the muscles? Give illustrations.

What is the effect if muscles are not used frequently?

In paralysis, what happens to the muscles?

What effect has exercise on the bones?

What causes some of the elevations seen on bones?

How are bones sometimes given a twist to one side?

What is said of the effect of exercise on the whole bony framework?

Besides muscle and bone, can other tissues and organs be influenced by exercise?

Of what are the tissues and organs composed?

What power has each cell?

What happens to these cells?

What is the effect of exercise upon these cells?

How does exercise influence the blood?

How does it act upon the organs which carry the blood?

How is breathing largely performed?

What effect has exercise on the lungs and on their supply of air?

How does exercise relieve the brain?

How does it bring sound sleep?

How does it give a good appetite?

What effect has exercise on the skin and other organs which carry off waste?

wnat can be accomplished by systematic exercise?

Give an illustration from Maclaren.

What is related of the poet Bryant?

What is said of deformities with reference to exercise?

Name some of these deformities.

By what should exercise be regulated?

Should exercise be varied, and how?

What is said about fatigue and exhaustion from exercise?

Should exercise be for strength?

What is usually the best time for active exercise?

When the strength fails rapidly between meals, when is exercise better undergone?

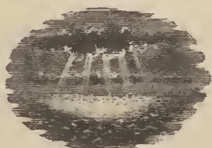
Why is exercise not good just before a meal? Why not just after a meal?

What is said about exercise in the early morning?

For what will children who exercise be better fitted?

Should books and studies be neglected?

What should be the aim in education?



CHAPTER VI.

MODES OF EXERCISE.

57. Physical Educational Exercises.—Physical educational exercises are those conducted in a systematic way with the view of favoring the growth and developing the resources of the body. In ancient Greece physical exercises were carried on in schools, called *gymnasia.* The term *gymnastics* is now frequently applied to regulated exercises of the body. These are usually performed with dumb-bells, clubs, weights, wands, bars, rings, ropes, ladders, and similar appliances.

58. Systematic Exercises without Apparatus.—Many useful exercises can be performed without any apparatus, under a system designed to call out the physiological action of the muscles. The term *calisthenics*, derived from two Greek words, meaning "beautiful" and "strength," is sometimes applied to systematic exercise conducted without special apparatus. In Fig. 20 is a representation of one of the positions taken in an exercise of this kind. This particular exercise is calculated to develop the chest as well as the limbs.

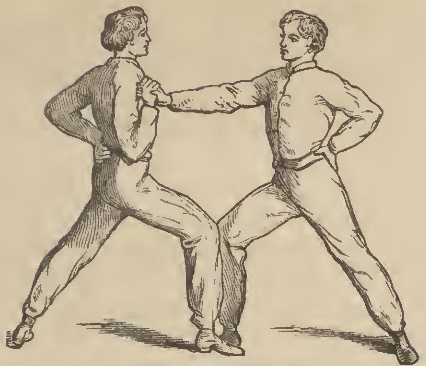


Fig. 20.—Calisthenic Exercise.

59. Movements to Promote general Suppleness.— Below is given a series of ten movements intended to promote general suppleness.* These movements are a good example of a useful and pleasant form of exercise without apparatus. They can be readily learned; and, if performed every day, will be of great benefit. They can be executed under the direction of the teacher, or of some pupil elected to the position of "leader." A wand can be used to beat time for the movements.

Position.— Heels together (as near as the configuration of leg will permit); hips thrown back; chest forward; head erect, with eyes to front; arms falling easy, with back of hand turned slightly to the front.

Exercise.— From this position bring hands to hips; thumbs back.

Head.— Turn twice to right, twice to left, once to right, twice to

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* Contributed by Miss Mary E. Allen, of the Boston Gymnasium for Ladies and Children, to *Wide Awake*, for October, 1881, in a series of Health Papers prepared for this popular magazine for the young.

left, once to right, back to front; drop hands to side and close to a fist.

Shoulder.— Raise right shoulder as high as possible four times, raise left four times, raise right and left alternately four times (left going up as right comes down), raise both together four times; drop hands to side.

Arm.— Throw right arm to horizontal at side (hand closed tight) four times, throw left four times, throw right and left alternately four times, throw both together four times, and bring fingers to tip of shoulders, upper arm horizontal, elbow pointing to front.

Forearm.— Throw right forearm to front on the elbow as a pivot, until the whole arm is horizontal (closing the hand at the throw), four times, throw left four times, throw right and left alternately four times, throw both together four times; and carry arms to side, horizontally stretched out, with palms up, and fingers closed into a fist.

Wrist.— Turn right fist *up* as far as possible four times (elbow stiff), turn left up four times, turn right and left up alternately four times, turn up together four times; and bring arms to horizontal stretch, front, palms down, fingers together and closed.

Hand.— Open right hand and stretch every finger four times, open left hand four times, open right and left alternately four times, open together four times; and bring hands to hips.

Trunk.— Turn as far as possible to right (holding trunk firm, turning face at same time, heels firmly planted), two times, turn to left two times, turn to right once, turn to left two times, turn to right once; and back to position.

Thigh.— Carry right leg across left (crossing left thigh as far up and as close as possible, knees stiff) four times, carry left leg across right four times, carry right and left across each other alternately eight times.

Leg.— Raise right leg as high as possible behind (on the knee as a pivot) four times (thigh remaining vertical and firm), raise left leg four times, raise right and left alternately eight times.

Foot.— Raise right foot on heel as high as possible four times, raise left four times, raise right and left alternately eight times.

The Position is very important, and the leader should insist upon it before the exercise begins. The body should *hold* the original position, with such changes as are indicated, firmly, so that only certain muscles are in use at once; thus, when the arm is used, the body should be stiff and firm.

Head Movements should always be slow, but firm, never with sudden force. Hence they are taken on the first beat of a measure only, or on 1 when counting 1, 2, 3, 4. All other movements are done with a spasmodic action, faster, using every other beat of 2–4 or 4–4 time, or on 1 and 3, in counting 4 That is, the movement is made on 1 and the return to position on 3. This exercise can be taken to any even 2–4 or 4–4 time, a *pot-pourri* of popular airs being pleasing, or any polka or quickstep. These movements aid in bringing muscles under the control of the will, and promote ease and grace of movement; also, as they force the mind and muscles to work together, they are a very valuable stimulus to the mental faculties; and, if enthusiastically and earnestly carried out, their influence will be felt in all mental work.

60. Gymnastic Apparatus.—Dumb-bells consist of two globular masses, with an easily-grasped handle between them (Fig. 21). Indian clubs are bottle-shaped masses of wood, the narrow end being shaped as a handle (Fig. 22). Dumb-bells of about a pound weight are sufficient for children under ten years of age. For older children they may be somewhat heavier. The clubs also should be light. It is a mistake to use heavy instruments too soon. The dumb-bells and Indian clubs are made to describe various curves and movements.

Fig. 21. Dumb-Bell.

Fig. 22. Indian Club.

61. How to Sit and Stand.—Children should early learn to sit and stand properly. Health, strength, and gracefulness will thus be acquired. The rule should be to hold the body as erect as possible both in sitting and standing. School-children often acquire bad habits of stooping over, or leaning too much to one side, while sitting at their desks or standing for recitations and other work. In this way they become ungainly, and sometimes deformed. An erect position favors the free action of the muscles, and also gives the internal organs, such as the heart, lungs, stomach, and liver, the fullest opportunity to perform their functions.

62. Out-Door Exercises.—The most healthful exercises are those which can be performed out of doors. Such exercises are both profitable and pleasurable. They are sometimes called natural exercises. Among the most valuable of these are walking, running, swimming, rowing, and riding. Leaping, climbing, skating, sledding, and similar sports, belong to the same class of exercises.

63. Walking.—Walking is an excellent form of exercise, developing many important muscles. It is chiefly performed by a series of complicated movements of the muscles of the legs; but when one walks properly, the muscles of the chest, abdomen, and upper limbs are also exercised. In walking, the entire weight of the body is supported first by one foot and then by the other, and thus each limb enjoys alternate rest. The trunk should be held erect, the head up, and the shoulders well back, while the arms

are swung to and fro. The foot should be well lifted, and the toes turned outwards. In coming down, the heel should first touch the ground lightly, then the rest of the foot to the toes, the heel being raised by the time the toes are reached. The whole foot should not be brought down flat upon the ground at once. Shoes should be worn broad enough to give every part of the foot its natural play.

64. Running.—Running is not simply fast walking. In running, only one foot is on the ground at a time. At some instants both feet are entirely removed from the ground. It is really a succession of slight leaps. It is a valuable exercise both to train the muscles and to give lung-power.

65. Swimming and Bathing.—Swimming is a useful exercise for development, and may prove to be a valuable art in time of danger. No real good can result, and harm may come, from reckless jumping, diving, swimming under water, and similar feats of daring sometimes indulged in by swimmers. The swimmer should not remain too long in the water; from a quarter to half an hour is usually enough. Surf-bathing serves to harden and strengthen the muscles and other organs. It should be practised with caution and moderation.

66. Rowing.—The labor of rowing should not be performed too much by the muscles of the back. Those who row much sometimes get strong backs, while their chests in front remain hollow, and their shoulders become rounded. Arms, trunk, and legs should all take part in rowing. The stroke should be

made by bringing the body to an upright position, and even carrying it a little beyond.

67. Riding.—Horseback-riding brings into use a large number of muscles, in checking and guiding the movements of the horse and in preserving the equilibrium of the rider. It is a refreshing and invigorating exercise, adding not only to health and strength, but also to courage and presence of mind. It is not suitable for the weak, nor for invalids, who cannot stand the jarring, or who are unable to control even the gentlest animal. Those who are not strong should use it in moderation at first, and should gradually increase the amount and character of the exercise. Heavy riding, such as hunting and steeple-chasing, is beneficial to the chest and chest muscles; but cannot be practised safely except by those who are strong. Carriage-riding is a good form of passive exercise, giving fresh air, change of scene, and pleasant occupation for the mind, but it does not call for sufficient muscular exertion to make it a means of development. Velocipede-riding and bicycle-riding have recently become popular, and are useful modes of exercise if practised in moderation.

68. Development of Both Sides of the Body by Exercise.—The tendency to one-sided development was referred to when speaking of the bones. It is by exercise that both sides of the body can be given an equal chance for development. Defective growth, and development of one side, can, with care, be prevented or remedied. Children should learn to bat, to throw, to lift, to use the hammer, etc., with either

hand. Boys should train themselves to kick a ball with one foot as well as with the other. Satchels and other burdens should not be carried too much in one hand or over one shoulder. Writing and sewing should be done with either hand. Whenever one limb is found to be weaker or less skilful than the other, the former should be exercised and trained until the inequality is overcome.

69. Open-Air Games or Recreative Exercises.— Open-air games, such as foot-ball, cricket, base-ball, hand-ball, tennis, jumping the rope, archery, etc., are important means of developing the body and keeping it strong and well. Wellington is reported to have said that England's soldiers were made on her foot-ball fields. In most of our popular games, as foot-ball, cricket, and tennis, the lower limbs have much the largest share of work. This should be remembered, and attention given to those games, such as archery, hand-ball, etc., in which the upper limbs take an active part. Gymnastic exercises afford the opportunity of developing the parts which are overlooked in work and games.

SYLLABUS.

Physical educational exercises are those conducted in a systematic way with the view of favoring the growth and developing the resources of the body.

Gymnastics are regulated exercises of the body, usually performed with dumb-bells, clubs, etc.

The term calisthenics is sometimes applied to systematic exercise conducted without apparatus.

Dumb-bells are globular masses, with an easily-grasped handle between them. Indian clubs are bottle-shaped masses of wood, the narrow end being shaped as a handle.

Both dumb-bells and Indian clubs should be light.

By learning to sit and stand properly, children acquire health, strength, and gracefulness. The rule should be to sit and stand erect.

School-children often acquire bad habits of stooping over, or leaning too much to one side. In this way they become ungainly, and sometimes deformed.

An erect position favors the free action of the muscles, and also gives the internal organs the fullest opportunity to perform their functions.

The most healthful exercises are those which can be performed out of doors: such as walking, running, swimming, rowing, etc.

Walking, which develops many important muscles, is chiefly performed by the legs, but the muscles of the chest, abdomen, and upper limbs should also be exercised.

In walking, the weight of the body is supported first by one foot and then by the other. The trunk should be held erect, the head up, and the shoulders well back, while the arms are swung to and fro.

The foot should be well lifted, and the toes turned outwards; and, in coming down, the heel should first touch the ground lightly, then the rest of the foot to the toes.

Shoes should be broad enough to give every part of the foot full play.

In running, only one foot is on the ground at a time. Sometimes both feet are removed from the ground, running being really a succession of slight leaps.

Running trains the muscles and gives lung power.

No real good can result, and harm may come, from reckless jumping, diving, swimming under water, and similar feats of daring.

From a quarter to half an hour is usually long enough for a swimmer to remain in the water.

Surf-bathing serves to harden and strengthen the muscles and other organs.

The labor of rowing should not be performed too much by the muscles of the back; but arms, trunk, and legs should all take part.

Horseback-riding brings into use a large number of muscles, in checking and guiding the movements of the horse, and in preserving the equilibrium of the rider. It is not suitable for some invalids.

Heavy riding, such as hunting and steeple-chasing, is beneficial to the chest and chest-muscles; but cannot be practised safely except by those who are strong.

Carriage-riding is a good form of passive exercise; but it does not call for sufficient muscular exertion to make it a means of development.

Velocipede-riding and bicycle-riding have recently become popular, and are useful modes of exercise if practised in moderation.

By exercise, both sides of the body can be given an equal chance for development.

Whenever one limb is found to be weaker or less skilful than the other, the former should be exercised and trained until the inequality is overcome.

Open-air games are important means of developing the body and keeping it strong and well.

In most of our games, the lower limbs, have much the largest share of work. Attention should be given to those games, etc., in which the upper limbs take an active part.

Gymnastic exercises afford the opportunity of developing the parts which are overlooked in work and games.

Questions for Review.

What are physical educational exercises?

What were the ancient Greek schools for physical exercise called?

What is meant by gymnastics?

With what are gymnastic exercises performed?

Under what system can exercises be performed without apparatus?

Define and give the derivation of the term calisthenics.

What are dumb-bells? What are Indian clubs?

Of what weight should dumb-bells and Indian clubs be for children?

How are dumb-bells and Indian clubs used?

How should children sit and stand?

What bad habits are often acquired by school-children?

What are some of the results of these bad habits?

What does an erect position favor?

What are the most healthful of all exercises?

What are these exercises sometimes called? Name some of them.

How is walking chiefly performed?

What muscles are exercised when walking is performed properly?

In walking, how is the weight of the body supported?

How are the different parts of the body held?

How should the foot be used? What sort of shoes should be worn?

What is said of the position of the feet in running?

What is running in reality?

What are trained and developed by running?

When may swimming prove to be a valuable art?

What feats sometimes indulged in by swimmers often lead to harm?

About how long should a swimmer remain in water?

How is surf-bathing useful? How should it be practised?

What muscles should not be over-used in rowing?

What defects of development are often observed in those who row much?

What portions of the body should take part in rowing?

How should the stroke be made?

How does horseback-riding bring into use the muscles?

What can be said of horseback-riding as an exercise?

Is it suitable for the weak?

What parts are benefited by heavy riding?

By whom alone should it be practised?

What is said of carriage-riding, velocipede-riding, bicycle-riding?

How can both sides of the body be given an equal chance for development?

How should children learn to bat, throw, lift, etc.?

How should a ball be kicked?

How should satchels and other burdens be carried?

How should writing and sewing be done?

How can inequalities of the limbs be overcome?

Name some open-air games which are important for health and development.

What is Wellington reported to have said?

Which limbs have the largest share of work in our popular games?

To what games should especial attention be given?

How can the parts overlooked in work and games be developed?

CHAPTER VII.

THE NERVOUS SYSTEM.

70. Regulation of the Machinery of the Body.—We have seen that the contraction of muscles results in the moving of bones and the parts attached to them. When the arm is stretched out, or bent upwards, why does it not always so remain? Why does not the leg always rest in one position? Why does not the eye always look in one direction? Our arms, and legs, and eyes move in this way or in that, because we wish or will them so to move. Something within us directs and regulates these movements. All machinery must be guided and controlled, or it will do harm rather than good. In the case of ordinary machines, as locomotives, steam-ploughs, etc., a human being sees that the boilers are properly filled with water, that the fires are neither too low nor too high, that the belts and wheels are well oiled, that the pipes and valves are all in proper condition. The machinery of the body, however, is regulated by a part of the machine itself. A muscle moves because something tells it to move. This order must come from somewhere, and must have a road by which to travel. It comes from the brain, and journeys by way of the spinal cord and nerves to the muscle.

71. The Parts of the Nervous System.—We have already learned that some of the bones of the head form a case or box, called the skull or cranium, and that a long, hollow tube is formed in the backbone, and is known as the spinal canal. The skull is filled with the organ called the *brain*, and the spinal canal with the *spinal cord*. The brain and spinal cord are connected; they are continuous masses of nervous matter. Running off from the brain and spinal cord to every part of the body are cords, called the *nerves*. The brain, spinal cord, and nerves, with little gray masses of nervous matter called *ganglia*, which are found here and there all over the body, make up the *nervous system*.

72. Gray and White Matter of the Nervous System.—The nervous system is composed of two kinds of tissue, usually spoken of as *gray matter* and *white matter*. The outside of the brain is made up chiefly of gray substance, the interior mainly of white. The external portions of the spinal cord are composed of white matter, the internal of gray. In the brain are some isolated masses of gray matter. Ganglia are also scattered here and there throughout the body. The nerves are formed of white matter. The gray substance of the nervous system is its active portion, the source of force or power. The white matter is made up of fibres or tracts for conveying impressions. These fibres transmit the messages which are sent to and fro throughout the body.

73. Divisions of the Brain.—Fig. 23 is a view of the left half of the brain. The large mass above, which shows many windings upon its surface, is the

cerebrum, or greater brain. It comprises about six-sevenths of the entire brain. It conforms to the shape

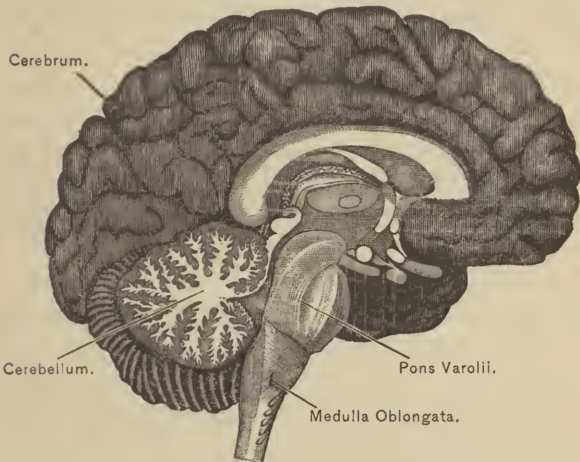

Fig. 23.—View of the Left Half of the Brain.

of the skull. Its external surface is made up of convolutions and fissures; that is, instead of being one uniform, smooth surface, it is composed of a curious system of hills and hollows. Underneath the cerebrum is a smaller mass, the cut surface of which presents a beautiful tree-like appearance. This is the *cerebellum*, or lesser brain. Two parts, called the *medulla oblongata*, or oblong marrow, and *pons Varolii*, are also seen in the picture. The medulla oblongata is about one inch long. By some it is regarded as the uppermost portion of the spinal cord. *Pons Varolii* means the bridge of Varolius, an Italian anatomist, named Varolius, having first described it.

74. Membranes of the Brain.—The brain is enclosed by two coats or membranes. The outer mem-

brane is called the *dura mater*, from *dura*, "hard," and *mater*, "mother." The name *dura* was applied to it because of its great hardness, or toughness. The term *mater* was given because the ancients had a fanciful notion that this membrane was the mother of all the other membranes of the body. The inner membrane, which is in close contact with the brain, is called the *pia mater*, or "delicate mother." Compared with the *dura mater* it is a very thin and delicate. Some anatomists speak of a third membrane, which is called the *arachnoid*, from Greek words meaning "resembling a spider's web." It is composed of two layers, one on the inside of the dura mater, and the other on the outside of the pia mater. These so-called layers of the arachnoid may be considered as parts of the other membranes.

75. Functions of the Brain.—The parts of the brain just described have many divisions and subdivisions, each of which probably has its own special use or function. The gray matter of the cerebrum is the chief organ of the *Mind.* It is hard to give a definition of mind; but we know it is that something within us by means of which we become conscious of sensations, by which we can fix our attention, and by which we can remember, think, judge, reason, and govern. We know that the cerebrum is the chief organ of mind, because when it is injured, diseased, or imperfectly developed, the mind is more or less unsound. Different parts of the cerebrum are probably concerned with different functions of the mind. In one portion we become aware of sensations of touch,

sight, hearing, taste, smell, pain, etc.; in another, attention, memory, judgment, reason, and other mental faculties, are seated; in still another, are centres from which go forth the orders or impulses which cause the muscles to move. The functions of the cerebellum have not been very clearly made out by physiologists. One of them seems to be to harmonize movements, that is, to cause the muscles to move in a steady and regular manner. It has been observed that when the cerebellum has been injured or diseased, walking or other movements of the limbs became unsteady and disorderly. The pons Varolii serves chiefly to connect the medulla oblongata with the cerebellum and cerebrum. Some important nerves arise in large part in its substance. In the medulla oblongata arise the nerves which are most essential to life, those which go to the face, throat, neck, lungs, heart, and stomach. A wound or disease of a very small portion of the medulla oblongata will sometimes cause death.

76. The Spinal Cord.—The spinal cord is connected with the medulla oblongata above, and extends downwards through the cavity or canal in the backbone. It is from fifteen to eighteen inches long, and has cracks or fissures running its whole length and dividing it into different parts.

77. The Nerves.—Nerves are given off from the brain and from the spinal cord in pairs. These are called the *cerebro-spinal nerves*—those coming directly from the brain being the *cranial nerves*, because they come from within the cranium or skull, and those from the spinal cord being the *spinal nerves*. (Fig. 24.)

Fig. 24.—A Back View of the Brain and of the Spinal Cord and its Branches.

78. The Cranial Nerves, or Nerves of the Brain. —Twelve pairs of nerves go off directly from the base of the brain. Figure 25 is a picture of the base of

Fig. 25.—The Base of the Brain.

the brain. As here seen, the nerves have been cut off before going into the openings in the skull. After passing through these holes they send branches off in various directions, some to the nose, some to the eyes, some to the ears, some to the scalp, forehead, and cheeks, some to the mouth, tongue, throat, and neck, some to the windpipe, lungs, heart, and stomach, and other organs of the abdomen.

79. The Spinal Nerves.—In the sides of the backbone or spinal column are numerous little holes, through which nerves pass to all parts of the trunk and limbs. These spinal nerves are connected indirectly with the brain as well as with the spinal cord. This is important to know; otherwise, it may not be understood how the brain receives messages from and controls all parts of the body. The spinal nerves appear to end when they reach the spinal cord; but the truth is, that in the spinal cord are tracts or roads along which messages can go up from the spinal nerves to the brain, and come down from the brain to the spinal nerves.

80. The In-coming and Out-going Nerves.—The nerves have been spoken of as if they all *went out* from the brain and spinal cord. More properly, some come in and some go out. In the spinal cord some nerve-fibres are running upwards, others downwards.

Fig. 26.—A Section of the Spinal Cord.

Both the out-going and in-coming nerves are in the same bundle up to a point near the spinal cord, where they divide. The middle part of Fig. 26 gives an idea of what would be seen if the spinal cord were cut across with a knife. In the central portion are two sets of horns. Between and outside of these are spaces, which look black in the picture but in reality are white, the horns being gray. The nerves, or their continuations, pass up and down the white parts or *columns*. The gray horns are centres of nerve force.

81. Sensory and Motor Nerves.—The in-coming nerves, those which carry news from all parts of the body to the brain, are also called *sensory nerves;* through them the brain gets acquainted with what is going on in and around the body. They are the nerves which bring about the sensations of touch, pain, temperature, etc. The out-going nerves, those which carry impulses or messages from the brain to all parts of the body, are also called *motor nerves*, because they chiefly go to muscles, and carry orders about movements. Each muscle or group of muscles has its own motor nerves. Certain parts of the brain are all the time in direct communication with certain muscles. Through some kind of an action in the brain, which we cannot fully comprehend, it is willed in the brain that a muscle shall move. Instantly the message goes to that muscle by way of the nerve tract in brain, spinal cord, and nerve, and the muscle obediently contracts. How the message is carried we cannot exactly say. Some think that it is simply by a sort of motion conveyed along the little molecules of the nerve tissue. It certainly is mysterious, and yet not much more so than the sending of messages along telegraph wires.

82. Reflex Action of the Spinal Cord and Brain.—Every movement performed by muscles is not directed by the brain. Sometimes muscular actions occur without the will or mind seeming to have anything to do with them. If your foot is tickled while you are asleep, you may draw it up without awaking. Here the mind does not seem to act, at least not in the ordinary way. Such a movement

is called a *reflex action.* The term *reflex* is derived from words meaning "to flow back again." Impressions are taken up by the sensory nerves, the ends of which are in the skin, and are carried by these nerves to nerve-centres in the gray horns of the spinal cord. From these centres they are reflected or thrown back along a motor nerve or nerves to the muscles of the foot and leg, and movement is the result. The brain is asleep and off guard, and does not take any note of such actions. Some reflex actions, such as coughing, sneezing, winking, etc., are performed through the brain. Walking, standing, piano-playing, and similar actions are also sometimes accomplished in a reflex manner, that is, without the interposition of the will.

83. The Sympathetic System of Nerves.—One set of nerves and ganglia found in the body is usually called the *sympathetic system of nerves.* One part of this system consists of a chain of gray ganglia, joined by a long cord, and situated on each side of the front of the spinal column in the neck, chest, abdomen, and pelvis. On or near the great organs, which are in the large cavities of the trunk, are networks of nerves and ganglia which belong to this system. Scattered here and there in little nooks and corners of the skull are also some of its ganglia. The different parts of the system are all connected, and are also united with the spinal cord or brain.

84. Physiology of the Sympathetic System of Nerves.—Nerves which go to blood-vessels are called *vaso-motor* nerves. Vaso-motor nerves are found in

all parts of the nervous system. They come sometimes directly from the brain and spinal cord, without getting mixed with the sympathetic system. Many of them, however, pass to the blood-vessels by way of the sympathetic ganglia. Blood-vessels have muscular tissue in their walls. The messages which travel along the vaso-motor nerves to the vessels cause them sometimes to contract or squeeze together, sometimes to dilate or become wider. In this way the supply of blood to different parts of the body, and particularly to the internal organs, is largely regulated through the sympathetic system.

Syllabus.

Our arms, and legs, and eyes move in this way or in that, because we wish or will them so to move. Something within us directs and regulates these movements.

All machinery must be guided and controlled.

The machinery of the body is regulated by a part of the machine itself. A muscle moves because something tells it to move.

The order to move comes from the brain, and journeys by way of the spinal cord and nerves to the muscle.

The skull is filled with the brain, and the spinal canal with the spinal cord.

Running off from the brain and spinal cord to every part of the body are cords, called the nerves.

The brain, spinal cord, and nerves, with little gray masses of nervous matter called ganglia, which are found here and there all over the body, make up the nervous system.

The nervous system is composed of gray matter and white matter.

The outside of the brain is made up chiefly of gray matter, the interior of white; the external portions of the spinal cord are composed of white matter, the internal of gray.

Isolated masses of gray matter are found in the brain, and ganglia are scattered throughout the body.

Nerves are formed of white matter.

The gray substance is the source of force or power; the white is made up of fibres or tracts, which convey impressions or messages.

The cerebrum, or greater brain, comprises about six-sevenths of the entire brain. Its external surface is made up of convolutions and fissures.

Underneath the cerebrum is the cerebellum, or lesser brain, the cut surface of which presents a beautiful tree-like appearance.

The medulla oblongata, or oblong marrow, is about one inch long, and is situated where the brain and spinal cord come together.

Between the medulla oblongata and the other portions of the brain is the pons Varolii, or bridge of Varolius.

The outer membrane of the brain is called the dura mater, or "hard mother." The inner membrane is called the pia mater, or "delicate mother."

Some anatomists speak of a third membrane, which is called the arachnoid, from Greek words meaning "resembling a spider's web." It is composed of two layers, one on the inside of the dura mater and the other on the outside of the pia mater.

Each division and sub-division of the brain probably has its own special function.

The gray matter of the cerebrum is the chief organ of the mind.

The mind is that something within us by means of which we become conscious of sensations, by which we can fix our attention, and by which we can remember, think, judge, reason, and govern.

We know that the cerebrum is the chief organ of mind, because when it is injured, diseased, or imperfectly developed, the mind is more or less unsound.

Different parts of the cerebrum are probably concerned with different functions of the mind.

One of the functions of the cerebellum seems to be to harmonize movements.

The pons Varolii serves chiefly to connect the medulla oblongata with the cerebellum and cerebrum. Some important nerves arise in its substance.

In the medulla oblongata arise the nerves which are most essential to life.

The spinal cord is from fifteen to eighteen inches long, and has fissures running its whole length and dividing it into different parts.

Nerves are given off from the brain and spinal cord in pairs, and are called the cerebro-spinal nerves.

The nerves which come directly from the brain are called the cranial nerves, those from the spinal cord the spinal nerves.

Twelve pairs of nerves go off directly from the base of the brain, passing through holes in the skull to the nose, eyes, ears, scalp, forehead, cheeks, mouth, tongue, throat, neck, windpipe, lungs, heart, stomach, and other organs of the abdomen.

Spinal nerves pass through little holes in the backbone to all parts of the trunk and limbs.

In the spinal cord are tracts or roads, along which messages can go up from the spinal nerves to the brain, and come down from the brain to the spinal nerves.

In the spinal cord some nerve-fibres are running upwards, others downwards.

In the central portion of the spinal cord are two sets of gray horns.

Between and outside of these horns are the tracts or columns of white matter.

The gray horns of the spinal cord are centres of nerve force.

The in-coming nerves, those which carry news from all parts of the body to the brain, are also called sensory nerves. They bring about the sensations of touch, pain, temperature, etc.

The out-going nerves, those which carry impulses or messages from the brain to all parts of the body, are also called motor nerves, because they chiefly go to muscles and carry orders about movements.

Certain parts of the brain are in direct communication with certain muscles. It is willed in the brain that a muscle shall move, and instantly the message goes to that muscle by way of the nervous system.

It is thought that impulses or messages are conveyed by motion of the little molecules of the nerve tissue.

Sometimes muscular actions occur without the will or mind seeming to have anything to do with them; these are reflex actions.

Impressions are taken up by the sensory nerves, the ends of which are in the skin, and are carried by these nerves to spinal centres. From these centres they are reflected or thrown back along a motor nerve or nerves to the muscles.

Some reflex actions, such as coughing, sneezing, winking, etc., are

performed through the brain; while walking, standing, piano-playing, and similar actions are also sometimes accomplished in a reflex manner.

The sympathetic system of nerves consists of a chain of gray ganglia, joined by a long cord, and situated on each side of the front of the spinal column in the neck, chest, abdomen, and pelvis.

In the large cavities of the trunk, and within the skull, are nerves and ganglia which belong to this system. The different parts of the system are all connected, and are also united with the spinal cord or brain.

Nerves which go to blood-vessels are called vaso-motor nerves, and are found in all parts of the nervous system. Many of them pass to the blood-vessels by way of the sympathetic system of nerves.

Messages which travel along the vaso-motor nerves cause the vessels to contract or dilate, and thus help to regulate the supply of blood to different parts of the body.

Questions for Review.

What results from the contraction of muscles?
Why do our arms, legs, and eyes move in certain directions?
What directs and regulates these movements?
Why must machinery be guided and controlled?
How are ordinary machines managed?
By what is the machinery of the body regulated?
Why does a muscle move?
Whence comes the order to move, and by what road does it travel
Where is the brain situated?
Where is the spinal cord situated?
What are the nerves?
What parts make up the nervous system?
Of what two kinds of tissue is the nervous system composed?
Where is the gray matter of the brain found?
Where is the white matter found?
Of what are the external portions of the spinal cord composed?
Of what are the internal parts composed?
What isolated masses are found in the brain?
Where are ganglia found?

Of what kind of tissue are the nerves formed?

What portion of the nervous system is the source of force or power?

What portion conveys impressions or messages?

What is the greater brain called?

How much of the entire brain does it comprise?

To what shape does it conform?

What are seen upon its external surface?

What is situated underneath the cerebrum?

What is the length of the medulla oblongata?

How do some regard the medulla oblongata?

What is the meaning of pons Varolii?

How many coats or membranes has the brain?

What is the outer membrane called?

Why were the terms "dura" and "mater" applied to it?

What is the inner membrane called?

What is the characteristic of this membrane?

What third membrane is sometimes spoken of by anatomists?

What is the derivation of the word arachnoid?

Of what layers is it composed?

Of what may these so-called layers of the arachnoid be considered as parts?

What is the chief organ of the mind?

What is the mind?

How do we know that the cerebrum is the chief organ of the mind?

With what are different parts of the cerebrum concerned?

Of what sensations do we become aware in one portion?

What faculties are seated in another part?

What centres are located in still another region?

What seems to be one of the functions of the cerebellum?

What has been observed when the cerebellum has been injured or diseased?

What purpose does the pons Varolii serve?

What arise in its substance?

What nerves arise in the medulla oblongata?

What would be the effect of a wound or disease of a very small portion of the medulla oblongata?

How long is the spinal cord?

How is the spinal cord divided?

How are nerves given off from the brain and spinal cord?

What is meant by the cerebro-spinal nerves?

Which are the cranial nerves?

Which are the spinal nerves?

How many pairs of nerves go off from the brain?

To what do the cranial nerves send branches?

Through what do the spinal nerves pass?

With what are the spinal nerves indirectly connected?

What tracts or roads are found in the spinal cord?

Do all the nerves go out from the brain and spinal cord?

In what direction do the nerve-fibres in the spinal cord run?

Up to what point are the out-going and in-coming nerves together?

What is situated in the central portion of the spinal cord?

Where are the white columns of the cord situated?

What is the function of the gray horns?

By what name are the in-coming nerves known?

Why are they so called?

What is brought about by them?

What are the functions of the out-going nerves?

What are they sometimes called, and why?

With what is each muscle or group of muscles supplied?

With what are certain parts of the brain in direct communication?

Explain the process by which the brain causes the muscle to contract.

How are messages probably conveyed along the nerve tracts?

Are all movements performed by muscles directed by the brain?

Give illustrations of movements occurring without the control of the will or mind.

What is a movement which occurs independently of the will or mind called?

Give the derivation of the term reflex.

Explain the process by which reflex actions take place.

Mention some reflex actions performed through the brain.

What set of nerves and ganglia is found in the body?

Of what does one part of the sympathetic system of nerves consist?

Describe the other portions of the sympathetic system.

With what is the sympathetic system connected?

What are vaso-motor nerves, and where are they found?

How do many of these nerves pass to the blood-vessels?

What sort of tissue is found in the walls of blood-vessels?

How is the supply of blood to different parts of the body largely regulated?

CHAPTER VIII.

SENSATION AND THE SPECIAL SENSES.

85. Sensation.—An impression made upon any part of the body to such an extent that the mind recognizes that something has been done, is a *sensation.* Through the nervous system impressions are received and given out, and we are put in communication with other beings and objects. If, for instance, we are struck, tickled, pinched, rubbed, cut, or burned, we have sensations of sticking, tickling, pinching, etc.; if we see a tree we have a sensation of sight; if we hear a voice or music we have a sensation of sound. For all sensations the individual must have (1) an apparatus to receive impressions, that is, sense-organs in the skin, eye, ear, etc.; (2) an apparatus to carry impressions to the brain, the in-coming or sensory nerves spoken of in the last chapter; and (3) an apparatus in the brain to convert the impressions into what becomes sensation to the mind. When the skin is touched, when light strikes the eye, or a sound the ear, when the tongue comes in contact with anything sweet, or the nose is greeted with an odor, sense-organs receive the impressions, and sensory nerve-tracts carry them to the brain, where we become conscious of a sensation.

86. The Five Special Senses.—The five special senses are feeling, seeing, hearing, tasting, and smelling. These are the five ways or channels by which the mind becomes acquainted with the outside world. Sometimes all or several of the senses act; sometimes only one is brought into service. We *hear* an apple fall, we look in the direction of the sound and *see* it, we *touch* it, picking it up, we *smell* its fragrance, and finally we *taste* it. Each and all of the senses have given some information about the apple. The blind man uses touch alone when he feels a piece of cloth to determine what it is.

87. Feeling or Touch.—The skin is the great organ of the sense of touch. Immense numbers of nerve filaments are found in the true skin. The ends of these take up impressions which arise from contact of the skin with any object. These impressions finally get into the brain as sensations of touch. By this sense of touch we learn whether bodies are hot or cold, rough or smooth, wet or dry. In some parts of the body, in the fingers and hands, for instance, the sense of touch is very delicate. If the skin is burned, *pain* is caused. The reason of this is that the nerves, which usually are only slightly excited by touch, are greatly excited by contact causing pain. When the skin comes in contact with a hot or cold body a peculiar sensation is caused, which some think is entirely distinct from touch. When a weight is raised, the sensation seems also to be not altogether one of touch.

88. The Media or Clear Parts of the Eye.—The organ of sight is the eye. Cutting through the mid-

dle of the eyeball from above downwards, and from before backwards, we get the appearance seen in Fig. 27. Going from before backwards, we first see the

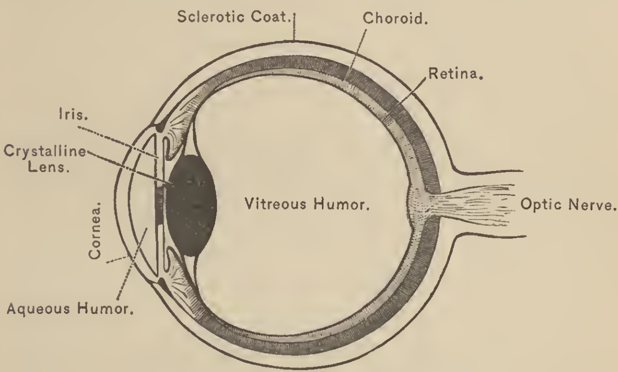

Fig. 27.—Section of the Eyeball.

clear part of the eye, or *cornea*, what is sometimes called, but wrongly, the "sight of the eye." The word cornea comes from *cornu*, "a horn," and this part of the eye is so called because it bears some resemblance to very thin horn. Next comes a little room or cavity, the front or *anterior chamber*, which contains a fluid known as the *aqueous* or *watery humor*. Hanging in this chamber is a circular curtain, the *iris*, which has a hole in it called the *pupil*. The word *iris* means "rainbow;" it is this curtain which gives the eye its peculiar color. The iris contains muscular fibres, which contract and expand, and so alter the size of the pupil. In bright light the pupil is small, in the dark it is large; and thus the amount of light admitted to the eye is regulated. Just behind the iris you come to a hard body, the *crystalline lens*, which is

perfectly clear, and has two sides curved outwards. Back of this lens is the *posterior chamber* of the eye, which is filled with a jelly-like mass, called the *vitreous* or *glassy humor.* The cornea, aqueous humor, pupil, crystalline lens, and vitreous humor are the *media of the eye*, placed between the outside light and the nerve of sight.

89. The Coats or Coverings of the Eye.—Besides the cornea in the front of the eye, this organ has three distinct coats or coverings. The outer protecting one is the *sclerotic* or *hard* coat; it forms, so far as it is visible, the "white of the eye." To this the muscles of the eyeball are attached. The middle coat is called the *choroid*, a word which means "like the skin;" it is like the true skin in that it contains a great number of blood-vessels. It is a very dark membrane, containing many pigment or paint cells. The object of these dark cells is to absorb some of the rays of light. If all the rays of light which strike the eyeball were allowed to enter the eye, and affect the nerve of sight, vision would be dazzled and confused. The third, inner coat of the eye is the *retina.* The word *rete* means a "net," and the retina has been compared to a network spread out over the inner surface of the eye. It is the sensitive, nervous coat of the eye.

90. The Nerve of Sight.—On page 75 is a picture of the base of the brain, to which attention was called in the last chapter. Near the front of this picture two tracts of nerve tissue can be seen crossing each other, somewhat like the letter X. These are the

optic nerves, or nerves of sight, forming at this point what is called the *optic chiasm* or *commissure*. *Chiasm* comes from a Greek verb, which means "to make the letter X;" and *commissure* signifies "a joining together;" and hence it can be seen why these names are given. Back of the place of crossing one of these nerve tracts goes to one side of the brain, while the other passes to the opposite side; in front of the chiasm one nerve proceeds through an opening in one of the bones of the head to the right eye, the other goes to the left. The nerve passes through the two outer coats of the eye, and becomes continuous with the inner coat or retina.

91. The Bending of Light in the Eye.—When light passes from one clear substance to another of different density, it is bent from the straight course which it has been taking. These clear substances will cause more or less bending of the rays of light according to their shape. A curved surface will cause a very considerable bending. A piece of glass with a double curve, like that of the crystalline lens, has a very decided refracting power. It will bend rays of light to a point. When rays of light come to the eye they strike first upon the curved cornea, which bends them a little from their course. After awhile they reach the crystalline lens, which bends them very decidedly; so much so as to actually cause the rays to fall upon the retina in such a way as to produce an image upside down.

92. Pictures upon the Retina.—When the photographer takes a picture he places his subject before

a box, with a hole in the front part of it. This is what is called the *camera obscura*, or dark chamber; it is coated or painted inside with some dark substance. At the end next to the person who is being photographed is an opening, containing a lens. At the other end is a piece of glass coated with a chemical substance, on which light acts very quickly. The rays of light coming from the subject strike the lens, and are bent by it in such a way that they fall right upon the chemical substance, and form there a picture. The eye may be compared to a camera obscura. The retina has, during life, a red color, due to a peculiar coloring matter, which is called *retinal red.* It is probably a chemical substance of extreme delicacy and sensitiveness, on which light waves from different objects, or objects of different colors, so act as to give rise to different changes in it. According to the kind of change effected will be the impression made on the nerve-ends, and conveyed back to the brain.

93. The Process of Seeing.—Rays of light pass through the beautifully clear media of the eye and through the pupil; they are bent by the crystalline lens so that they fall directly upon the retina. They cause a picture of the object from which they come to be made upon the retina. They produce a stir in the retina. They probably set up in it some kind of minute motion. We commonly say that light makes an impression on the retina. This stir, or motion, or impression, travels from the retina back along the optic nerves to the brain; and in the brain, in some way not fully understood, it becomes the sensation of sight, and the object is seen right side upwards.

94. The Organ of Hearing.—Only second to sight in importance is the sense of hearing. The organ of hearing is the *ear*, of which you have a view (Fig. 28). It consists of three parts, the external ear, the middle ear, and the internal ear. The *external ear* includes the projecting and curiously curved part commonly called the ear and the little tube or canal, the *external*

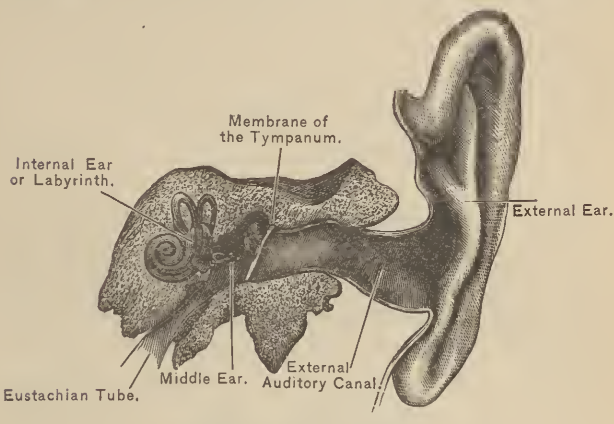

Fig. 28.—View of the Ear.

auditory canal, which can be seen extending inwards from the outside. This canal is about one inch long. At its inner end it is closed by a membrane called the *membrane of the tympanum*. The *middle ear* is a little cavity just inside of this membrane. This cavity is called the *tympanum* or drum. A canal or tube about one and a half inches long runs from this middle ear or tympanum to the throat. It is called the Eustachian tube, after an anatomist, Eustachius, who first described it. Both the Eustachian tube and middle ear are lined with delicate mucous membrane. The *internal ear* is

also called the *labyrinth*, because of its complex character. This internal ear or labyrinth is made up of curiously shaped canals and cavities in the bones.

95. The Nerve of Hearing.—The auditory nerve, or nerve of hearing, is one of the nerves given off directly from the brain. It proceeds from the base of the brain by bony passages to the internal ear, in the cavities and canals of which it is distributed, ending in minute plates and hair-like filaments. This nervous portion of the organ of hearing is bathed all the time in a fluid which is within the labyrinth.

96. The Process of Hearing.—A sound like that of a voice, a bell, or a cannon sets the air around into vibration. This vibration is carried as a wave of sound to the external ear. It passes into the external auditory canal, and strikes against the membrane of the tympanum, which is also made to vibrate. These vibrations are communicated to little bones within the ear, by which they are carried along to the labyrinth or internal ear. The liquid in the labyrinth, and finally the little nerve ends, take up the motion, which is conveyed along the trunk of the auditory nerve to the brain and becomes there the sensation of hearing. This is the usual process. Sound, however, instead of coming through the external canal of the ear, may reach the labyrinth by the bones of the head. If a watch is placed against the forehead, or against the teeth, its ticking can be heard very distinctly, the sound being carried by way of the bones of the head to the internal ear.

97. Taste.—If salt, sugar, vinegar, or a bitter medicine is placed on the tongue, it produces a peculiar sensation—it is tasted, for the tongue is the organ of taste. The tongue is supplied by two nerves, branches from one going to the front, and from the other to the back part of the organ. Impressions are carried by one or both of these nerves to the brain. The mucous membrane which covers the tongue is raised into little points or papillæ, and to these go little nerve filaments and blood-vessels. Through these points impressions of taste and other impressions also are received.

98. Smell.—The sense of smell is brought about by an arrangement very similar to that for the other senses. The nose, as has already been learned, is lined with mucous membrane. At the front part of the base of the brain are the nerves of smell, or olfactory nerves, one on each side. They are of large size and club-shaped (Fig. 25). From these nerves of smell a large number of little nerve branches go down through minute holes in the floor of the skull to the mucous membrane which lines the nostrils and the cavities connected with them. This membrane, like the tongue, has scattered all over it little papillæ or projections, in which the delicate nerve-branches end, or, perhaps, more properly, begin. Odors carried by the air enter the nose, act upon the nerve-ends, and the impressions made are hurried back to the great nerves of smell in the brain, and the sensation of smell results.

Syllabus.

Impressions are received and given out through the nervous system.

A sensation is any impression made upon any part of the body to such an extent that the mind recognizes that something has been done.

Sensations require (1) an apparatus to receive impressions; (2) an apparatus to carry impressions to the brain; (3) an apparatus in the brain to convert the impressions into what become sensations to the mind. Sense-organs in the skin, eye, ear, etc., receive the impressions, and sensory nerves carry them to the brain.

The five special senses are feeling, seeing, hearing, tasting, and smelling. Sometimes all or several of the senses act; sometimes only one is brought into service.

The skin is the great organ of the sense of touch.

Nerve-ends in the true skin take up impressions of contact. These impressions finally get into the brain as sensations of touch.

If the skin is acted upon by cutting, burning, etc., pain is caused.

The nerves which are only slightly excited by touch are greatly excited by contact causing pain.

The organ of sight is the eye.

The media of the eye are the cornea, the watery humor in the front chamber of the eye, the pupil, the crystalline lens, and the glassy humor in the posterior chamber.

The iris is a circular curtain hanging in the watery humor. The pupil is a hole in this curtain. The iris gives the eye its color. It contains muscular fibres, which by contracting and expanding alter the size of the pupil.

The eye has three coats—(1) the outer sclerotic or hard protecting coat; (2) the middle or choroid coat, containing many dark pigment cells, which prevent too much light from entering the eye; (3) the inner coat or retina, which is the sensitive or nervous portion of the eye.

The optic nerves, or nerves of sight, which go to the retina cross at the base of the brain, one nerve-tract going to one side of the brain, while the other passes to the opposite side.

When rays of light come to the eye they strike first upon the curved cornea, which bends them a little from their course. The crystalline lens bends them still more, so as to actually cause them to fall upon the retina in such a way as to produce an image upside down.

The eye can be compared to the photographer's camera obscura, or dark chamber.

The retina has during life a red color, due to a peculiar coloring matter, which is called retinal red.

Retinal red is probably a chemical substance of extreme delicacy and sensitiveness, on which light waves from different objects so act as to give rise to different impressions.

Rays of light cause a picture of the object from which they come to be made upon the retina. They make an impression on the retina, which travels back along the optic nerves to the brain.

The organ of hearing is the ear, which consists of three parts—the external, middle, and internal ear.

The external ear includes the part commonly called the ear, and the little canal which can be seen extending from the outside inwards. The inner end of this canal is closed by a membrane called the membrane of the tympanum.

The middle ear is a little cavity called the tympanum or drum. The Eustachian tube runs from it to the throat.

The internal ear is called the labyrinth, because of its complex character. It is made up of curious canals and cavities in the bones.

The auditory nerve, or nerve of hearing, proceeds from the base of the brain by bony passages to the internal ear.

A sound sets the air into vibration. This wave of sound passes into the external ear canal and causes the membrane of the tympanum to vibrate.

The vibrations of the membrane of the tympanum are communicated to little bones within the ear, by which they are carried along to the labyrinth or internal ear. The liquid in the labyrinth, and finally the auditory nerve, take up the motion, which is conveyed to the brain and becomes there the sensation of hearing.

Sound sometimes reaches the labyrinth by the bones of the head.

The tongue is the organ of taste.

In the tongue are branches from two nerves, those from one to the front, those from the other to the back part of the organ.

The mucous membrane which covers the tongue is raised into little points or papillæ, and to these go little nerve filaments and blood-vessels. Through these points impressions of taste, and other impressions also, are received.

From the nerves of smell at the base of the brain branches go down through holes in the skull to the mucous membrane of the nostrils.

Odors act upon the nerve-ends in the mucous membrane.

QUESTIONS FOR REVIEW.

What are the functions of the nervous system?

What is a sensation? Give illustrations.

What three things are necessary in order that sensations may be produced?

Give illustrations of the forms of apparatus for sensations.

What are the five special senses?

What are the functions of these senses?

How many of the senses may act at one time?

Give an illustration of the action of all the senses.

Give an illustration of the use of only one sense.

What is the organ of the sense of touch?

What are found in the true skin?

How are sensations of touch brought about through the nerves of the skin?

Of what do we learn by the sense of touch?

Where is the sense of touch very delicate?

Explain the difference between the sensation of touch and that of pain.

What results when the skin is touched by a hot or cold body?

What results when a weight is raised?

What is the organ of sight?

What is the cornea? Why is it so called?

What is the name of the little room or cavity in the front of the eye?

What fluid does the anterior chamber of the eye contain?

What curtain hangs in this chamber?

What is the pupil of the eye?

What is the meaning of the word "iris"?

What does the iris give to the eye? What does the iris contain?

How is the admission of light to the eye regulated?

Where is the crystalline lens? Describe it.

Where is the posterior chamber of the eye? What does it contain?

What are the media of the eye?

How many coats or coverings has the eye?

What is the outer coat of the eye called?

What does this coat form and what are attached to it?

What is the middle coat of the eye called? Why?

What does the choroid coat contain?

What is the object of the dark cells of the choroid?

What is the inner coat of the eye called? Why?
What is the function of the retina?
Where do the optic nerves cross?
What is the meaning of the words chiasm and commissure?
What is the course of the optic nerve tracts behind the chiasm?
With what coat of the eye is the optic nerve continuous?
What happens to a ray of light when it passes from one clear substance to another?
What is the effect of a curved surface? What of a double curve like that of the crystalline lens?
Describe the course of rays of light after reaching the eye.
Describe a camera obscura.
To what is the red color of the retina during life due?
What is the probable nature of retinal red? How does it act?
Describe the process of seeing.
What is the organ of hearing?
Of what three parts does the ear consist?
What does the external ear include?
What is the membrane of the tympanum?
What is the middle ear? What is its cavity called?
What tube runs from the middle ear to the throat?
With what are the Eustachian tube and middle ear lined?
What is the internal ear also called? Why?
Of what is the internal ear or labyrinth composed?
What is the name of the nerve of hearing?
Where does the nerve of hearing originate? Describe its course.
In what is the nervous portion of the organ of hearing bathed?
Describe the usual process of hearing.
Instead of coming through the external auditory canal, in what other way may sound reach the internal ear? Give an illustration.
What is the organ of taste?
What nerve branches are found in the tongue?
What are their functions?
What are the papillæ of the tongue?
How is the sense of smell brought about?
With what is the nose lined?
Where are the nerves of smell situated and what are they called?
Describe the course of the branches of the nerves of smell.
Describe the process of smelling.

CHAPTER IX.

CARE OF THE NERVOUS SYSTEM AND SENSE ORGANS.

99. Importance of Caring for the Nervous System.—The importance of carefully guarding the nervous system is very evident. The brain, being the governing part of the body, must be kept in good health, or the machinery of the system, which it directs, will be allowed to jangle and get out of tune. The spinal cord, along which some of the messages to and from the brain centres are carried, and which contains centres of its own, must also be sound, or the performance of its functions will not be properly effected. The sensory nerves must not be broken or injured, or impressions will not be conveyed smoothly upwards to the spinal cord and brain. The motor nerves must be intact in order to receive and convey the messages from the brain as they are sent.

100. Exercise of the Brain.—As the brain is the chief organ of the mind, its regular exercise will improve the mental powers. Much can be done in childhood towards establishing good habits of mind. Careful training of the senses will help in this direc-

tion, as our knowledge really comes from sensations. Even the higher faculties of the mind, such as attention, will, memory, and judgment, are improved by exercise of the brain. Children sometimes seem to look without seeing, and to listen without hearing; they should learn to observe closely and attend to what they observe. In reading, they should try to understand clearly every word and thought. Study will improve the mind, and will not injure the body, if proper care is taken to preserve the health by regular habits of eating, sleeping, exercise, and recreation. Mental labor must not be carried to excess.

101. Causes of Disease of the Brain and Nervous System.—Alcoholic drinks, such as whiskey, brandy, gin, wine, beer, ale, etc., are often the cause of serious diseases of the nervous system. When large quantities of alcohol are taken in a short time, drunkenness is produced, chiefly through its effects upon the brain. If its use is continued, the faculties of the mind become impaired. Sometimes the tissues and vessels of the brain become so altered that they cannot properly perform their functions. We should learn from this that, while alcohol may have its uses, it should not be abused. Continued care, anxiety, or excitement will also have a tendency to weaken and depress the brain. Prolonged exposure to the sun, or to excessive heat, with fatigue, is also a cause of disease of this organ.

102. Paralysis.—A condition known as *paralysis*, or *palsy*, is sometimes the result of disease or injury of some part of the nervous system. The term paralysis comes from a Greek word meaning to "loosen"

or "disable." It is an affection characterized by a loss or diminution of power. The arm that is completely paralyzed cannot be lifted from the side; the palsied leg will drag like a dead weight. The muscles no longer act as they do in health. The disease or injury which causes the paralysis may be situated in the brain, in the spinal cord, or in the nerves. A vessel may break in the brain, causing a blood-clot to form, and this clot destroys the centres which govern and direct muscular movements. The spinal cord may be crushed, or may be diseased, so that messages cannot travel up and down it, or so that its centres cannot act, and spinal paralysis results. Disease or injury of a nerve causes paralysis by cutting off communication between the muscles and the brain or spinal cord. When the serious nature of paralysis is considered, the importance of carefully guarding the nervous system from harm and overstrain will be recognized.

103. Sleep.—Sleep has well been called "tired nature's sweet restorer." Without sleep the brain would soon wear out. The work and turmoil of the day keep the brain in a state of constant activity. Wear and waste always go hand in hand with activity; hence, the brain becomes exhausted. Sleep helps to renew and rebuild. During sleep the voluntary muscles are at rest, and breathing, circulation, and temperature are diminished. About eight hours out of the twenty-four is the proper allowance of sleep for most adults. Children, and those who are weakly or hard-worked, will generally require more than eight hours.

104. Defects of Sight.—Two of the most common defects of vision are short-sight and long-sight, which are generally due to a faulty shape of the eyeball. In short-sight, or near-sightedness, the globe of the eye is too long, and rays of light are bent to a focus in front of the retina. Objects can then only be seen clearly when they are close to the eye. Concave glasses are employed to correct this defect. In long-sight, or far-sightedness, the globe of the eye is too short, and hence rays of light from an object at an ordinary distance come to a focus behind the retina. Convex glasses must be used. Sometimes, instead of the eyeball being simply too long or too short, it is irregular in shape. Glasses made with special curvatures in different directions are then necessary. The eye can be adjusted to see near or distant objects by what is called the function of accommodation, which is performed by the crystalline lens, the curvature of this body increasing or diminishing. As age advances, however, the lens becomes less elastic and its curvature cannot well be increased, so that convex glasses are also required for this condition.

105. How to Preserve Good Sight.—The sight often becomes poor because the eyes are sadly abused, especially in childhood and youth. Near-sightedness, in particular, which is said to be rapidly increasing in all civilized countries, is frequently acquired during school-life. At home and at school every precaution should be taken to counteract the injurious effects of protracted use of the eyes at a near point, as, in reading, writing, drawing, sewing, and similar work.

Study-rooms should be well lighted. The light should be abundant, steady, and not glaring, and should enter from the left side. Desks should be inclined, so as not to compel the pupil to bend over too much when at work. School-books should be printed in large, clear type, and the pages should not be too broad. Whenever defective vision is suspected, the eye should at once be examined. If the condition of the sight was determined before entering school, much misery in after life would often be saved.

106. Color-Blindness.—A peculiar defect of sight is called color-blindness. Usually, those who are color-blind are not able to distinguish between certain colors. The most frequent form of color-blindness is that for red; that for green comes next in frequency; rarely that for blue will be found. The term "Daltonism" is applied to color-blindness, after Dalton, a famous English chemist, who was red-blind, and was the first to call scientific attention to the subject, describing his own case in 1794. Children should be taught early to attend to colors. The color-sense can be improved by training, and sometimes the defect is apparent rather than real.

107. Care of the Ears.—The ears, like the eyes, should be watched and guarded. They are often injured by introducing too much cold water, and by boring and working at them. The ears can be cleaned with a soft, dry towel, or with a little warm water. The introduction of solid instruments, such as pins, probes, and ear-spoons, may injure the auditory canal, or even the drum of the ear. The ear may be injured even

by probing it roughly with the finger. If a foreign body gets into the ear, it can usually best be removed by gentle, steady syringing with warm water. Whenever the hearing is affected, when noises are heard in the ears, or when a discharge from this organ is noticed, a physician should be called.

108. Cultivation of the Senses.—All of the senses can be improved by cultivation. Great delicacy of touch can be acquired by practice, as is seen in musicians, sculptors, mechanics, and sometimes to a remarkable extent among the blind. A girl, named Laura Bridgman, through severe sickness occurring in her infancy, lost sight, hearing, taste, and smell; but she was taught to write, and to read and talk with her fingers, learning more with her one sense of touch than some do with all their senses. The eye can be trained to see farther and better. The hearing can be improved by listening carefully, and trying to distinguish different sounds. The Indian, who depends so largely on his senses, usually has acute sight and hearing. Persons with "musical ears" can tell the slightest differences in notes. Even taste and smell can be improved by cultivation. If the senses are the inlets or channels by which knowledge enters the mind, those who cultivate most thoroughly each and all of them will, in the end, have acquired the most knowledge.

SYLLABUS.

The nervous system should be carefully guarded.

Regular exercise of the brain will improve the mental powers. The senses should be carefully trained.

Children should learn to observe closely and attend to what they observe. In reading, they should try to understand clearly every word and thought.

Mental labor must not be carried to excess.

Alcoholic drinks are often the cause of serious diseases of the nervous system. Continued care, anxiety, or excitement, and exposure to the sun, or to excessive heat, with fatigue, are also causes of nervous diseases.

Paralysis sometimes comes on as the result of disease or injury to the nervous system. It is an affection characterized by loss or diminution of power.

The disease or injury which causes the paralysis may be situated in the brain, in the spinal cord, or in the nerves.

Without sleep the brain would soon wear out. Sleep helps to renew and rebuild the brain worn and wasted by active work.

During sleep the voluntary muscles are at rest, and breathing, circulation, and temperature are diminished.

About eight hours out of the twenty-four is the proper allowance of sleep for most adults; but children, and the weakly or hard-worked, will sometimes require more.

In short-sight the globe of the eye is too long, and rays of light are bent to a focus in front of the retina. Concave glasses are employed to correct this defect.

In long-sight the globe of the eye is too short, and rays of light come to a focus behind the retina. Convex glasses must be used.

Sometimes the eyeball is irregular in shape, and glasses made with special curvatures are necessary.

The eye can be accommodated for near or distant objects by the curvature of the crystalline lens increasing or diminishing. As age advances the lens becomes less elastic and its curvature cannot well be increased, so that now convex glasses are also required for this condition.

The sight often becomes poor because the eyes are abused in childhood and youth. Near-sightedness is often acquired during school-life.

Study-rooms should be well lighted. The light should enter from the left side.

Desks should be inclined, so as not to compel the pupil to bend over too much when at work. School-books should be printed in large, clear type, and the pages should not be too broad.

Whenever defective vision is suspected, the eye should at once be examined. Before entering school, the condition of sight should be determined.

The most frequent form of color-blindness, or "Daltonism," is for red; that for green comes next; rarely that for blue will be found.

Children should be taught early to attend to colors. The color-sense can be improved by training, and sometimes the defect is apparent rather than real.

The ears should be watched and guarded. They are often injured through ignorance and carelessness.

The ears are injured by introducing too much cold water into them and by boring and working at them too much.

The ears can be cleaned with a soft, dry towel, or with a little warm water. If a foreign body gets into the ear it can usually best be removed by gentle, steady syringing with warm water.

Whenever the hearing is affected, when noises are heard in the ear, or when a discharge from this organ is noticed, a physician should be called.

All of the senses can be improved by cultivation; and if the senses are the inlets or channels by which knowledge enters the mind, those who cultivate them most thoroughly will, in the end, have acquired the most knowledge.

Questions for Review.

Why should the brain be kept in good health?

Why should the spinal cord be sound?

Why must the sensory nerves not be broken or injured?

Why must the motor nerves be intact?

What will be the effect of regular exercise of the brain on the mental powers?

When can much be done towards establishing good habits of mind?

What is said of careful training of the senses?

What is said of the higher faculties of the mind?

How should children learn to observe?

How should they read?

What effect will study have upon the mind and body?

What diseases are often caused by alcoholic drinks?

How is drunkenness produced?

What effect has alcohol on the tissues and vessels of the brain?

Name some other causes of diseases of the nervous system.

From what is the term paralysis derived?

By what is it characterized?

Give some illustrations of forms of paralysis.

Where may the disease or injury which causes the paralysis be situated?

Give an example of the manner in which paralysis may be caused by brain disease.

How is spinal paralysis produced?

How does disease or injury of a nerve cause paralysis?

What does the serious nature of paralysis teach?

What has sleep been called?

What would be the effect of going without sleep?

What organs are at rest and what functions are diminished during sleep?

What is the proper amount of sleep for most adults?

How much sleep do children and the weakly or hard-worked require?

What are two of the most common defects of vision?

To what are they frequently due?

What is the condition in short-sight?

What kind of glasses is employed to correct short-sight?

What is the condition in long-sight?

What kind of glasses are used to correct this defect?

What other defect of the eyeball besides its being too long or too short is sometimes found?

How is this defect corrected?

How is the crystalline lens adjusted to see near or distant objects?

What effects has age on the function of accommodation?

What kind of glasses is required to correct the defect of sight which results from advancing years?

How does sight often become defective?

When is near-sightedness frequently acquired?

What precaution should be taken with reference to the eyes?

How should study-rooms be lighted?
How should desks be inclined? Why?
How should school-books be printed?
What should be done when defective vision is suspected?
What should be done before entering school?
What is color-blindness?
What is the most frequent form of color-blindness?
What is the origin of the term "Daltonism"?
What is said about teaching children to attend to colors?
How are the ears often injured?
How can the ears be cleaned?
Should solid instruments be introduced into the ear?
What course should be taken when any serious affection of the ear is present?
Can the senses be improved by cultivation? Give illustrations.
Who in the end will have acquired the most knowledge?

CHAPTER X.

THE BLOOD.

109. What Blood Is.—The blood of living man is a red, warm fluid. It has been well called the vital or life-giving fluid. Good blood in proper quantity usually means good health. It is found almost everywhere in the body; only a few tissues, such as the nails and hair, will not bleed when stuck or cut. Blood cannot be seen coursing along in the human body, even in rosy cheeks, where much of it is near the surface. In order to study it in a living animal, however, physiologists sometimes look at the web of a frog's foot, which is very thin and contains many blood-vessels.

110. Quantity of Blood in the Living Body.—The quantity of blood in the human body is about one-thirteenth or one-fourteenth of the weight of the body. If a man weighs one hundred and fifty-six pounds, about twelve pounds of this weight will be blood. About one-fourth of this blood is distributed in the heart, lungs, large arteries, and veins; one-fourth in the liver; one-fourth in the muscles; and one-fourth in other organs.

111. Composition of the Blood.—When blood first flows, it appears to the naked eye like a perfectly simple red fluid. It is not, however, as simple in composition as it appears, as can be learned by looking at a drop of blood under the microscope. It will then be seen to be made up of a solid and a liquid portion. The liquid, which is colorless, is called *plasma*; the solid part is composed of *corpuscles*. These corpuscles, or "little bodies," are of two kinds—the *red corpuscles* and the *white corpuscles*. In Fig. 29 is a view

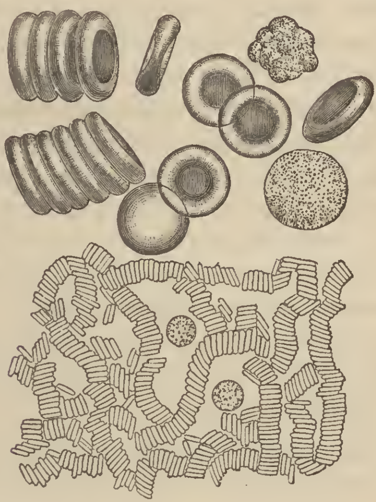

Fig. 29.—Red and White Corpuscles of the Blood Magnified.

of some of the appearances presented by these corpuscles, red and white.

112. The Red Corpuscles.—The red corpuscles are flat, circular disks, dimpled on each side like a

shirt-button. In the figure are views of them looking at them in front and edgeways. They have a curious fashion of sometimes sticking together like a roll of pennies, as is also shown. A single red corpuscle really looks yellowish; but when many of them are seen together they look red. They give to the blood its red color. The blood has been compared to a stream of water filled with an immense number of very little red fishes, the red corpuscles. One drop of blood contains as many as a million.

113. The White Corpuscles.—The white corpuscles are somewhat larger than the red. They are usually globular. They will, however, even while one is looking at them with the microscope, change their shape several times—one moment being globular, the next pear-shaped, the next three-cornered, and so on. They are colorless, and are less numerous than the red corpuscles, healthy blood containing only one white corpuscle to about four or five hundred red. It is supposed that the white corpuscles become in time changed into the red. When the proportion of white corpuscles to red is much increased, a serious disease is the result.

114. Clotting or Coagulation.—If fresh blood is put into a bowl, it soon becomes like jelly. If it is left standing for some hours, it will separate into two parts—one a red, solid mass, the *clot*, and the other a clear liquid, which is called *serum*. The whole process is spoken of as *clotting* or *coagulation*. In the plasma, or liquid part of blood, a substance called *fibrin* forms. This is made up of very delicate

threads or filaments. These run in all directions like an extremely fine net-work. The corpuscles get caught in this net-work, and in this way the clot is formed. The serum is the plasma with its fibrin removed; the clot is equivalent to the corpuscles with fibrin added. It is not yet known exactly where the fibrin, which plays such an important part in clotting, originates. It forms in the blood after it has left the body. It has been thought probable that it is in part, at least, made out of the white corpuscles breaking in pieces.

115. Clotting of Blood in the Living Body.—In health, blood does not clot in the living body. It is fortunate that this is the case. The smallest islet of flesh becomes barren and dead without its supply of blood. If a vessel should be stopped by a clot, the parts to which the vessel goes would not receive this supply. This clotting sometimes occurs in grave diseases. Clotting sometimes serves a useful purpose when blood-vessels are cut or otherwise injured. The bleeding is checked by the clots plugging the open mouths of the vessels.

116. Composition of Serum.—Even the serum, or liquid part of the blood which separates from the clot, is not a simple fluid. It contains more than water. It is largely made up of albumen, the same substance that is found in the white of egg. This albumen is composed of the four great elements carbon, hydrogen, nitrogen, and oxygen, sometimes called *albuminoids.* Albumen, and substances like it, are found here and there all over the body. Our food, out of which

the blood is made, contains also the albuminoid elements. Vegetables are largely made up of oxygen, hydrogen, and carbon; while most animal food contains all these, and nitrogen in addition. Some parts of vegetables, however, contain all four elements, and the *fat* of animals is composed only of the oxygen, hydrogen, and carbon. The serum of the blood can be dried, and it will then readily burn. The part which burns is chiefly albumen; and in burning, this substance gives rise to carbonic acid, water, and ammonia. Carbonic acid contains carbon and oxygen; water contains hydrogen and oxygen; and ammonia contains nitrogen and hydrogen. In burning, the albumen breaks up into its different elements, some of which unite with oxygen from the air, and, as stated, carbonic acid, water, and ammonia are formed. Albumen is, as the chemists would say, a body which can be burned or oxidized.

117. Composition of Fibrin.—Fibrin is a substance very similar in composition to albumen, although the two are not identical. It is an albuminoid; like albumen, it is composed of carbon, hydrogen, nitrogen, and oxygen. Fibrin, albumen, and other albuminoids, largely make up the important tissues of the body, muscle, nerve, gland, etc.

118. Water of the Blood.—In one hundred parts of serum about ninety parts are water; and in one hundred parts of wet corpuscles about fifty-six or fifty-seven parts are water. The entire blood contains nearly eighty per cent. of water. It is "thicker than water" chiefly because of the immense numbers of

corpuscles which it contains; although the solid matters dissolved in the plasma also help to render it thicker and heavier.

119. Mineral Substances in the Blood.—In addition to the corpuscles, the fibrin, the albumen, and the water, the blood also contains minute quantities of minerals or salts. When blood is dried and then burned, a small amount of *ash* will always be left. This ash, if examined carefully, will be found to contain numerous mineral substances, the most important of them being iron, potassium, sodium, calcium, chlorine, sulphur, and phosphorus. These substances, although present in such very small quantities, are essential to healthy blood.

120. Uses of the Blood.—The feeding of the tissues of the body is carried on chiefly by the fluid part of the blood. The tissues take nutritive material from the blood, and the blood itself is fed from the food taken into the stomach. This blood builds bone and brain, liver and lungs, marrow and muscle; from it are derived bile, tears, saliva, and other secretions. Even the vessels which carry the blood are made from it. It supplies each tissue with the kind of material it needs. It carries oxygen to every part which requires oxygen. The blood also collects the waste matters of the body and conveys them to the organs which cast them out.

Syllabus.

Good blood in proper quantity usually means good health.

Only a few tissues, such as the nails and hair, will not bleed when stuck or cut.

Blood can be studied in a living animal in the web of a frog's foot.

The quantity of blood in the body is about one-thirteenth or one-fourteenth of the body-weight.

Blood is made up of a solid and a liquid portion. The liquid is called plasma; the solid part is composed of red and white corpuscles.

Red corpuscles are flat, circular disks, dimpled on each side. They sometimes stick together like a roll of pennies. They give to the blood its red color. One drop of blood contains as many as a million.

White corpuscles are usually globular; but often change their shape.

Healthy blood contains one white corpuscle to about four or five hundred red.

If blood is left standing in a bowl for some hours, it will separate into a red, solid mass, the clot, and a clear liquid called serum.

A substance called fibrin forms in the plasma. This fibrin is made up of delicate threads, which constitute a fine net-work, in which the corpuscles get caught, and in this way the clot is formed. The serum remains behind.

It has been thought probable that fibrin in part, at least, is made out of the white corpuscles breaking in pieces.

In health, blood does not clot in the living body.

Clotting sometimes serves a useful purpose when blood-vessels are cut or otherwise injured. The bleeding is checked by the clots plugging the open mouths of the vessels.

Serum contains more than water. It is largely made up of albumen.

Albumen is composed of carbon, hydrogen, nitrogen, and oxygen—elements sometimes called albuminoids.

Food, out of which the blood is made, contains the albuminoid elements.

The serum of the blood can be dried and burned. The part which burns is chiefly albumen; and in burning, this substance gives rise to carbonic acid, water, and ammonia, partly through union of its elements with the oxygen of the air.

Fibrin is an albuminoid.

Fibrin, albumen, and other albuminoids, largely make up the important tissues of the body.

The entire blood contains nearly eighty per cent. of water.

Blood contains minute quantities of minerals or salts, the most important of them being iron, potassium, sodium, calcium, chlorine, sulphur, and phosphorus.

The blood feeds the tissues, and the food taken into the stomach feeds the blood. It supplies each tissue with the kind of material it needs.

The blood collects the waste matters of the body and conveys them to the organs which cast them out.

Questions for Review.

What is blood? What has it been called?

Where is it found?

How do physiologists study blood in a living animal?

To what is the quantity of blood in the body equal?

How is this blood distributed?

Of what two portions is the blood composed?

What are the two kinds of corpuscles called?

Describe the red corpuscles.

In what manner do the red corpuscles often come together?

What is the color of a single red corpuscle?

To what has the blood been compared?

How many red corpuscles does one drop of blood contain?

How do the white corpuscles compare in size with the red?

What is the shape of the white corpuscles?

What is said about the white corpuscles changing shape?

What is said about their color?

How do the white corpuscles compare in number with the red?

What becomes of the white corpuscles?

What is the result when the white corpuscles increase out of proportion to the red?

What happens if fresh blood be allowed to stand in a bowl?

Into what two parts does the blood separate?

What is the process of separation called?

What substance is found in the plasma, or liquid part of blood?

Describe the process by which a clot is formed.

To what is the serum equivalent?

To what is the clot equivalent?

What is known about the origin of fibrin?

Does blood clot in the healthy living body?

What would happen if blood clotted in the living body?

What useful purpose is sometimes served by clotting?

Of what is serum largely composed?

Of what elements is albumen composed?

What are these elements sometimes called?

Where is albumen found?

Does the food contain albuminoid elements?

Of what are vegetables largely composed?

What does animal food contain?

What is said of drying and burning serum?

What substance chiefly burns?

In burning, to what does albumen give rise?

What is the composition of carbonic acid, of water, and of ammonia?

How would the chemists describe albumen?

What is fibrin? Of what is it composed?

What are largely made up by the fibrin, albumen, and other albuminoids?

What is the proportion of water in serum?

What is the proportion of water in wet corpuscles?

What is the per cent. of water in the entire blood?

What makes blood "thicker than water"?

What is contained in the ash of blood?

How are the tissues fed?

How is the blood fed?

Name some of the uses of the blood.

What is collected by the blood?

CHAPTER XI.

THE CIRCULATION OF THE BLOOD.

121. Machinery for Distributing the Blood.—As the blood builds every tissue, the body must have machinery to distribute this blood. The *heart* is the pump which propels, and the *blood-vessels* are the pipes which convey, the red fluid of life to every little particle of tissue. The blood is constantly travelling round and round to every part of the system. This journey of the blood through the body is called the *circulation*, the word *circulate* meaning to "move round." In ancient times it was said that "all roads led to Rome," because Rome was the centre of the world's activities. In like manner, in regard to the circulation, all roads lead to the heart. The roads by which the blood travels are blood-vessels of three kinds, called *arteries*, *veins*, and *capillaries*. The blood goes out of the heart and finds its way through these vessels back to the heart again.

122. The Heart.—The heart (Figs. 30, 31) is a hollow organ, situated in a space in the chest between the two lungs. It is conical in shape, its pointed end, or apex, hanging downwards. Its usual weight is ten to twelve ounces. It is not a single chamber or cavity. It is divided, in the first place, from above downwards into a

right and left half; and then each of these halves is again subdivided into an upper and lower cavity. If the head is placed on the left side of the chest, a peculiar double sound, or rather two sounds, something like *lubb dup*, *lubb dup*, can be heard. To hear these sounds best, the listening ear should be about on a level with the fifth rib, or over the space between the fifth and sixth ribs, and a little to the left of the breast-bone. These are the sounds of the heart, which is ceaselessly working.

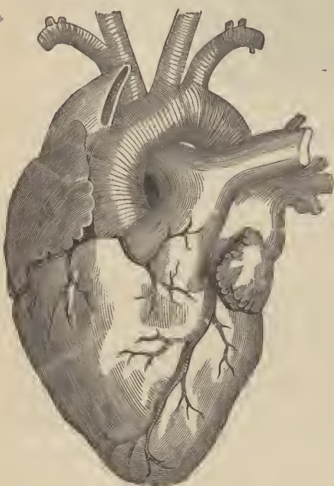

Fig. 30.
The Heart and Large Blood-vessels.

123. Valves of the Heart.—The word *valve* comes from a Latin word which means "folding-doors." A valve is usually a little lid or door of some kind, so made as to permit a fluid to pass in one direction, but not to come back. In the common pump is a valve which allows the water to come up, and then closes to prevent its return, so that it is compelled to flow out of the spout. Between the upper and lower cavities on each side of the heart, and also between the lower cavities and the vessels which go out from them, are valves, which allow the blood to flow forward, but prevent it getting back again, so that the circulation is kept up steadily in one direction.

124. Arteries.—The term *artery* comes from Greek words meaning "to contain air." The ancients believed that the arteries were air-tubes, because they usually found them empty after death. The first and largest of the arteries is given off directly from the

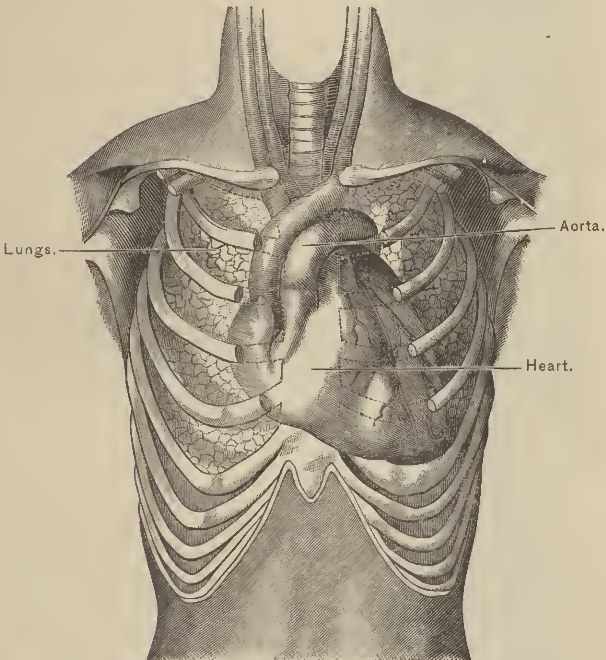

Fig. 31.—A View of the Chest, Showing the Heart, the Lungs, and the Large Blood-vessels.

left lower cavity of the heart. It is called the *aorta*, from Greek words meaning to "support," because it is supported or suspended from the heart. It goes up from the heart, makes a great curve from right to left, and then descends through the trunk in front of

the backbone. It sends off branches to all parts of the body. In Fig. 32 is a view of the aorta and some of its branches. The first of these go to the organs in the chest, abdomen, and pelvis. A large artery goes to each leg, dividing and subdividing until the toes are reached. Each arm is supplied with a main artery also, which divides at the elbow into two branches, and these subdivide again and again down to the very finger-tips. In Fig. 33 is a view of the arteries of the arm and forearm and their subdivisions. If the ends of the fingers are placed along the front of the wrist, near its thumb side, a steady beat will be felt. This is the impulse of the blood in an artery. It is the "pulse" which the doctor feels. On the temples this impulse can also be made out. It could be felt in hundreds of places, if the blood-vessels were not so covered by the tissues. A large artery goes up each side of the neck, and this has an internal branch which passes through a hole in the skull to the brain, and an external branch which supplies the neck and face, as shown in Fig. 34.

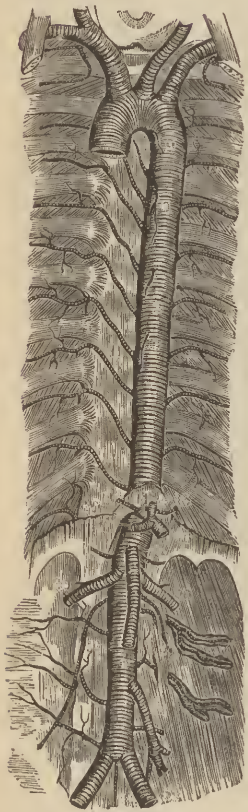

Fig. 32.
The Aorta and its Branches.

125. The Veins.—The vessels which bring the blood back to the heart are called *veins*, the Latin *vena* meaning a "pulse," or "vein." The arteries begin in one great vessel, the aorta; the veins end in two great vessels, both of which open into the right upper chamber of the heart. Veins, like arteries, are found in all parts of the body. Instead of starting as large vessels, like the arteries, they begin as minute tubes, and come together to form larger and larger trunks. They have thinner walls than the arteries. The veins have *valves*, like little watch-pockets, along their inner walls. They open the way the blood travels (Fig. 35). Their mouths are always towards the heart.

Fig. 33.
Arteries of the Forearm.

126. The Capillaries.—Arteries do not open into veins, nor veins into arteries; but communication between them is made by another set of very fine vessels, the *capillaries*, from the Latin *capillus*, a hair. All the arteries of the body may be said to end, and all the veins to begin, in these capillaries.

127. Contractions of the Heart.—The heart is a muscular organ, and it is the property of a muscle to

contract. The muscular fibres which compose the walls of the heart run in various directions around its cavities. When these fibres contract, they squeeze together the heart-walls. If a hollow India-rubber ball, with a hole in it, is filled with water, and is firmly grasped and twisted in the hand, the water

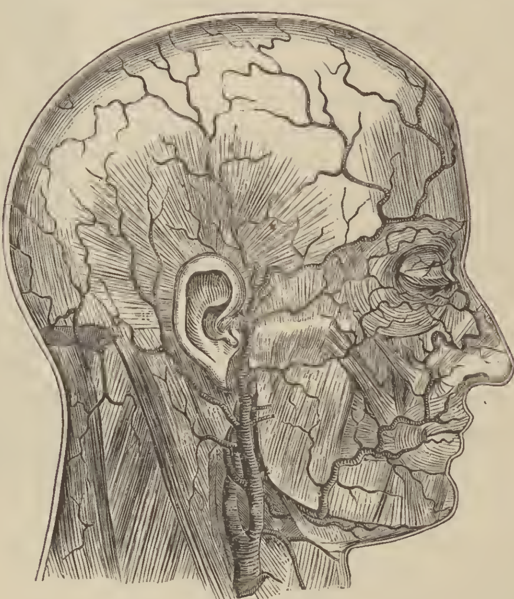

Fig. 34.—The Arteries of the Head and Face.

will be driven out through the opening. The hand and fingers contain many muscles, and it is through their contractions that the force which expels the water is exerted. During the passage of blood through the heart, a series of squeezings or contractions takes place.

128. Description of the Course of the Circulation. —All the blood from the capillaries of the body is collected by veinlets and veins, and is carried to the upper cavity of the right side of the heart. As soon as this cavity is full, its walls begin to contract, and the blood within is squeezed through the valve into the lower cavity of the same side. The valve between the two cavities is composed of little flaps, and, as the blood fills the lower cavity, it gets behind these flaps and pushes them shut. From the right lower cavity of the heart a large vessel, called the *pulmonary* or *lung* artery, goes out and sends branches to both lungs. Where this artery begins, the opening is guarded also by a valve. The walls of the heart-cavity squeeze together, and the blood rushes forward into the artery, and is prevented by the valve from reflowing. Carried by the pulmonary artery and its branches, the blood is distributed to millions of capillaries in the lungs. From these it passes into *pulmonary* or *lung* veins, the largest of which finally convey it to the upper of the two cavities of the *left* side of the heart. The journey through the left heart is very much like that through the right. The upper cavity contracts and forces the red stream onward through a valve into the lower. This left lower cavity next contracts. The blood cannot flow back, so it pushes forward with a great wave into the aorta, the opening into which is also guarded by a valve. On and on the blood travels until the capillaries of all parts of the body, except the lungs, are reached.

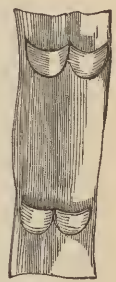

Fig. 35.—A Vein Opened so as to Show the Valves in Parts.

129. The Circulation through the Liver.—The liver is supplied with blood for its nourishment by branches of the aorta. In addition, the blood which circulates in the stomach, intestines, and some other organs, is collected by a large vein and carried into the liver. The liver acts upon the blood, so as to render it better fitted for the uses of the body. It is thought that the liver destroys a poisonous material which forms in the blood in other parts of the system. The liver also manufactures sugar to be used by the system. After the blood has been changed in the liver, it is collected by veins and conveyed to the right side of the heart.

130. The Spleen.—The spleen, a dark, red organ, about five inches long, and weighing about six or seven ounces, is situated to the left of the stomach. It has no ducts or canals. Its exact functions are not known. Things are carried to the spleen by blood-vessels, and after they have been changed in the spleen they are probably carried away in the blood again.

131. How the Tissues are Supplied by the Blood.—The walls of the capillaries are very thin. Everywhere these capillaries surround little islets of tissue. Nutritive materials from the blood soak through the thin walls of the capillaries into these little islets. If a bladder containing water, in which sugar has been dissolved, is placed in a vessel of pure water, the water in the vessel after a short time will taste of the sugar. The dissolved sugar has passed through the membrane. In a similar way materials pass out of the blood into the tissues.

SYLLABUS.

The blood is distributed to the tissues by the heart and blood-vessels.

The journey of the blood through the body is called the circulation.

Blood-vessels are of three kinds, called arteries, veins, and capillaries.

The heart is a hollow organ in the chest between the two lungs. It is divided into a right and left half, and each of these halves is subdivided into an upper and lower cavity.

The sounds of the heart can be best heard about on a level with the fifth rib, or between the fifth and sixth ribs, a little to the left of the breast-bone.

Between the upper and lower cavities on each side of the heart, and also between the lower cavities and the vessels which go out from them, are valves.

The ancients believed that the arteries were air-tubes, because they usually found them empty after death.

The largest artery, called the aorta, is given off directly from the left lower cavity of the heart. It sends off branches to all parts of the body—to chest, abdomen, pelvis, legs, arms, neck, face, brain, etc.

Veins bring the blood back to the heart.

The veins end in two great vessels, both of which open into the right upper chamber of the heart.

Veins have thinner walls than the arteries.

The veins have valves like little watch-pockets along their inner walls.

Communication is made between the arteries and veins by a set of very fine vessels called capillaries.

The muscular fibres which compose the walls of the heart contract and squeeze together the heart-cavities, and thus force onwards the blood.

All the blood from the capillaries is collected by veins and carried to the right side of the heart; it passes from the right upper to the right lower cavity, and thence by way of the pulmonary artery to the lungs; from the lungs it is conveyed by the pulmonary veins to the left upper cavity of the heart; it moves onward through the left cavities of the heart into the aorta, and thence to the general system.

The blood which circulates in the stomach, intestines, and some

other organs is collected by the portal vein and carried into the liver.

The liver destroys a poisonous material which forms in the blood in other parts of the system. It is also a source of sugar.

The spleen, a dark, reddish organ, about five inches long, and weighing about six or seven ounces, is situated in the upper part of the abdomen, to the left of the stomach. Its exact function is not known.

The tissues take from the fluid portion of the blood what they need for their nourishment.

Nutritive materials soak through the thin walls of the capillaries into little islets of tissue.

Questions for Review.

What propels the blood?

What conveys it to the tissues?

What is the journey of the blood through the body called?

What are the three kinds of blood-vessels?

What is the heart?

Where is it situated?

What is its usual weight?

Into how many cavities is it divided?

Describe the sounds of the heart.

Where are these sounds best heard?

From what is the word valve derived?

What is a valve? Give an example of a valve.

What valves are found in the heart?

From what is the term artery derived?

Where is the first and largest artery?

Why is it called the aorta?

Describe the course of the aorta.

To what organs do the first branches of the aorta go?

How are the legs and arms supplied with arteries?

Where can the impulse of the blood in an artery be felt most readily?

At what other points can it be felt?

Why cannot the pulse be felt in hundreds of places where arteries are found?

Describe the course of the arteries which go to the brain, neck, and face.

What are the vessels which bring the blood back to the heart called?

How do the veins end? How do they begin and increase?

How do their walls compare with those of the arteries?

Describe the valves of the veins.

What are the capillaries?

Of what sort of tissue is the heart composed?

How do the muscular fibres of the heart run?

What is the effect of the contraction of these fibres?

Illustrate by a hollow India-rubber ball the method in which muscular action causes fluid to be expelled from a cavity.

What takes place during the passage of blood through the heart?

How is the blood from the capillaries of the body collected?

To what cavity of the heart is the blood carried by the veins?

Describe the journey of the blood through the right side of the heart.

What large vessel goes out from the right lower cavity of the heart to the lungs?

How is the opening of this vessel guarded?

Describe the distribution of the blood to the capillaries of the lungs.

Into what does the blood pass from the capillaries of the lungs?

To what cavity of the heart do the pulmonary veins convey the blood?

Describe the journey of the blood through the left side of the heart and the general system.

How is the liver supplied with blood for its nourishment?

What is done by the portal vein?

What are some of the functions of the liver?

What becomes of the blood after it has been changed in the liver?

What is the spleen? Where is it situated?

What is known about its functions?

Describe the manner in which nutritive materials get into the tissues from the capillaries.

Illustrate by a bladder containing water in which sugar has been dissolved.

CHAPTER XII.

FOOD.

132. Why we Eat.—A witty writer has said that some people eat to live and others live to eat. It is certain that unless we eat we cannot live. Our tissues are constantly wasting, because every part of the body is constantly at work. Walking, writing, breathing, thinking, lead to waste. This waste must be made good by what we eat and drink, by what we take into the system. We eat that we may make blood, and from the blood each part of the body takes something to keep it alive and growing. What we eat does not go at once into the blood; it must first be got ready. It is true that doctors sometimes throw medicine, liquid food, or even fresh blood itself, directly into a patient's blood; but this is something unusual and unnatural, and it is only done in extreme sickness, and when food cannot be taken in ordinary ways.

133. Food.—Anything which goes to nourish the body, which is used to make good its wear and waste, is *food*. It might be said that food is anything we eat or drink, were it not that we sometimes take substances into our mouths and stomachs which are

not food; and some, indeed, which do more harm than good to the body. Eggs, milk, meat, bread, sugar, butter, salt, and water are well-known articles which contain the essentials of a real food; on them one could live, grow, and develop.

134. Digestion.—*Digestion* must be performed before food, of whatever kind it may be, becomes blood. The word *digestion* means the act of dissolving or separating into parts. It is a process of breaking up and changing the food until it gets just right for the blood.

135. The Different Classes of Food-Stuffs.—We have learned that albumen, of which the serum of the blood is mainly composed, contains the four great elements, carbon, hydrogen, nitrogen, and oxygen; and also that the food which makes the blood, and the tissues and organs of the body, are largely formed of these elements. Foods, or food-stuffs, are of different kinds, according to the proportions or arrangement of these elements. *Nitrogenous* food-stuffs contain these four elements; but they are most important because of their nitrogen. They are the only forms of food which contain nitrogen. They are sometimes called *albuminoids*, because of the albumen which abounds in them. The best examples of nitrogenous food are found in lean meat, eggs, and milk. *Sugars and starches*, which constitute another class of food-stuffs, contain carbon, hydrogen, and oxygen, with a large proportion of the last. Sugar is chiefly obtained from fruits and vegetables, but sometimes comes from the animal world, as when obtained from honey and milk. Starch is abun-

dant in such food as wheat, corn, rye, rice and potatoes. *Fats and oils*, a third kind of food, also contain carbon, hydrogen, and oxygen, but comparatively little of the last. They also are derived both from the animal and vegetable world; for example, the fat of meats, of butter, and of milk from the animal kingdom; from the vegetable, olive oil, palm oil, and cocoa butter. *Mineral substances*, such as common salt, lime, and iron, form a necessary part of food, although they are not needed in large quantities. Our chief drink, *water*, is one of the most important articles of food. It makes up the greater part of the weight and bulk of the body.

136. Remarks on the Different Kinds of Food.— Food-stuffs get into the blood after undergoing certain changes. Our food should contain different articles in proper proportion. Milk, and food prepared from it, are among the best articles of diet, because milk contains every one of the different classes of food,—nitrogenous, sugary, fatty, and mineral, and a good supply of water. It is usually easy of digestion. If compelled to live on a single article, milk would be the best. The term "flesh-food" is sometimes applied to the different kinds of meat—beef, mutton, pork, fowl, fish, etc. These, like eggs, abound in nitrogenous material. Breads supply us with plenty of sugary and starchy matters. They, however, contain also gluten, which is a form of nitrogenous or albuminous food. The potato is composed of water, starch, and a little albumen. Fruits are largely made up of water and sugar, and are useful as food, as well as

agreeable to the taste. What is called a "mixed diet" is the best. Body and mind are kept in the best condition by using both animal and vegetable food.

137. Quantity of Food Required.—The quantity of food required to maintain health varies greatly according to certain circumstances, such as age, activity, season, and climate. The young need more than the old. Those who are active, who work hard either physically or mentally, require a large supply of good food. In cold weather and cold climates more food, and of a stronger quality, is needed than in warm seasons and hot climates. Animal food should not be taken oftener than twice daily. The amount of animal and vegetable food combined, should not exceed thirty ounces in the twenty-four hours; and for the majority of persons an average of twenty-four ounces of mixed solid food, a third only of which should be animal, is sufficient. The amount of fluid taken in any form should not exceed the average of twenty-four ounces daily.*

138. Cooking.—Good cooking is of great importance. The best food may be rendered almost worthless by bad preparation. Articles are cooked to fit them for digestion and improve them in taste. Sometimes cooking is necessary to make food *safe.* A minute worm called the *trichina spiralis*, or "spiral hair-like worm," sometimes is present in different forms of pork, and in beef. If the pork or beef is eaten raw or underdone, this worm may get into the human body and produce a painful disease.

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* B. W. Richardson's "Diseases of Modern Life."

139. When and How to Eat.—Persons in ordinary health should eat at regular intervals. Three meals a day, from five to six hours apart, should be taken. Eating between meals should be avoided. The stomach needs to rest between its efforts at digestion. We should eat slowly, carefully chewing solid food. We should be cheerful while eating. The brain and the stomach cannot both be worked hard at the same time without injury to one or the other; therefore, we should not think deeply, nor allow our minds to be excited, while eating. Pleasant conversation assists digestion. The old saying that one should leave the table feeling hungry is not true; but, on the other hand, we should not eat until we are uncomfortable. A disease known as dyspepsia, which means "difficult digestion," is usually caused by errors of diet—by taking food at irregular hours, or of improper quality or quantity, or by not devoting sufficient time to eating and drinking.

140. Drinks.—Tea, coffee, and cocoa, when properly used, are admirable drinks and very serviceable, particularly for grown people. They soothe and stimulate the nervous system, and prevent the tissues from wasting too rapidly. They should not be taken in excess. One cup of each a day is enough. Alcoholic drinks, such as wine, ale, beer, brandy, and whiskey, have their uses, but should not be employed as common drinks. When the system is much reduced by disease or by accident, they may be of much service. Their use should be directed by physicians.

141. Pure Water.—Of all drinks, pure water is the

best. By pure water we mean water free from injurious impurities. Absolutely pure water is not found in nature, but can be obtained by carefully condensing steam. Rain-water, where it falls in the country, is a good example of a soft and comparatively pure water. If water is acted upon by sewer-gas, or receives foul matters of any kind, it becomes a source of disease. Water obtained from lakes or rivers should be carefully filtered before being used.

Syllabus.

The tissues of the body are constantly wasting because every part of the body is constantly at work. This waste is made good by what we eat and drink.

We eat that we may make blood.

Anything which goes to nourish the body, which is used to make good its wear and waste, is food.

Eggs, milk, meat, bread, sugar, butter, salt, and water contain the essential of a real food.

Digestion is a process of breaking up and changing the food until it gets just right for the blood.

Foods, or food-stuffs, are of different kinds, according to the proportion or arrangement in them of the four great elements, carbon, hydrogen, nitrogen, and oxygen.

Our food should contain the different food-stuffs in proper proportion.

If compelled to live on a single article of diet, milk would be the best, because it contains every one of the different classes of food-stuffs, and is usually easy of digestion.

"Flesh-food," such as beef, mutton, pork, fowl, and fish, abounds in nitrogenous material.

Breads supply us with plenty of sugary and starchy matters, and contain also gluten, which is a form of nitrogenous food.

The potato is composed of water, starch, and a little albumen.

Fruits are largely made up of water and sugar.

A mixed diet, one containing both animal and vegetable food is the best.

The young need more food than the old; the active require a large supply.

In cold weather and cold climates, more food, and of a stronger quality, is needed than in warm seasons and hot climates.

Nitrogenous food-stuffs contain these four elements; but they are most important because of their nitrogen. They are sometimes called albuminoids, because of the albumen which abounds in them.

Lean meat, eggs, and milk are the best examples of nitrogenous food.

Sugars and starches, another class of food-stuffs, contain carbon, hydrogen, and oxygen, with a large proportion of the last.

Sugar is chiefly obtained from fruits and vegetables, but sometimes from honey, milk, and other animal sources.

Fats and oils also contain carbon, hydrogen, and oxygen, but comparatively little of the last. They also are derived both from the animal and vegetable world, from milk, butter, olive oil, etc.

Mineral substances, such as common salt, lime, and iron, form a necessary, but small part of our food.

Water is one of the most important articles of food.

Animal food should not be taken more than twice daily.

The amount of animal and vegetable food combined should not exceed twenty-four to thirty ounces in the twenty-four hours, a third only of which should be animal.

The amount of fluid taken in any form should not exceed the average of twenty-four ounces daily.

Good cooking is of great importance.

Articles are cooked to fit them for digestion and improve them in taste.

Sometimes cooking is necessary to make food safe. A minute worm, called the trichina spiralis, sometimes is present in raw meat; and if the meat is eaten raw or underdone, this worm may get into the human body and produce a painful disease.

Three meals a day, from five to six hours apart, should be taken.

We should eat slowly, and we should be cheerful while eating.

We should neither leave the table hungry, nor should we eat until we are uncomfortable.

Dyspepsia is a disease usually caused by errors of diet.

Tea, coffee, and cocoa are admirable and serviceable drinks, but should not be taken in excess.

Alcoholic drinks should not be employed, except for special purposes, and under the direction of physicians.

Of all drinks, water free from injurious impurities is the best.

Questions for Review.

Why are the tissues of the body constantly wasting?

How is this waste made good?

Why do we eat?

What must take place before what we eat gets into the blood?

Are substances ever introduced directly into the blood?

Give illustrations.

Define the word food.

Why do we not define food as anything that we eat or drink?

Name some well-known articles which contain the essentials of a real food.

What is the meaning of the word digestion?

What is the process of digestion?

What four elements does the albumen of the blood contain?

Does the food also contain these elements?

What different kinds of food or food-stuffs are known?

What do nitrogenous food-stuffs contain?

What are they sometimes called, and why?

What do sugar and starches contain?

From what is sugar obtained?

In what kind of food does starch abound?

What do fats and oils contain?

From what are fats and oils derived?

What is said of mineral substances as articles of food?

What is said of water?

To be most useful, what should our food contain?

Why is milk one of the best articles of diet?

To what is the term "flesh-food" applied?

In what material does "flesh-food" abound?

What sort of matters are supplied by breads?

What form of nitrogenous food is found in breads?

What is the composition of fruits?

What is the best diet?

How is the quantity of food required to maintain health varied?

Do the young or old need most food?

What do the active require?

What effect has weather and climate?

How often daily should animal food be taken?

What amount of animal and vegetable food combined should be taken in twenty-four hours?

What amount of fluid should be taken daily?

Why are articles cooked?

Is cooking ever necessary to make food safe? Illustrate.

How many meals a day should be taken?

Why should eating between meals be avoided?

How should we eat?

What should be our condition of mind while eating?

What is the meaning of the word dyspepsia? How is it usually caused?

What is said of tea, coffee, and cocoa?

What is said of alcoholic drinks?

What is the best of all drinks?

Is absolutely pure water found in nature?

What is a good example of a soft and comparatively pure water?

How may water become a source of disease?

What should be done with water obtained from lakes and rivers before using it?

CHAPTER XIII.

DIGESTION.

142. The Organs of Digestion.—The organs of digestion are the different parts of the *alimentary* or *food canal*, and the glands communicating with it. This canal is a long tube, which is at some places wide and at others narrow, at some straight and at others twisted. It begins as the *mouth* and *throat*. In the back part of the chest it is a narrow, straight tube, the *gullet* or *œsophagus*, the word œsophagus meaning "food-carrier." It continues into the abdomen as the large bag or pouch called the *stomach*, and as the *intestines* it becomes a long tube, wound and turned upon itself in a curious fashion.

143. What Takes Place in the Mouth.—When liquid food is taken into the mouth, it leaves it very quickly, passing by way of the throat and gullet to the stomach. If the food is solid or partly solid, it is chewed by the teeth and acted upon by the secretions of the mouth. The mucous membrane of the mouth is full of little glands which pour out a watery fluid which mixes with the food. Three pairs of large

glands also pour their secretion, called *saliva*, into the mouth. The largest of the three is the *parotid gland*, which is beneath the skin in front and below each ear. The word parotid means "near the ear." One of the other two is situated just beneath the back part of the lower jaw, and the other in the floor of the mouth under the tongue. Saliva has the peculiar property or function of converting starch into sugar. This turning of starch into sugar is one of the useful processes of digestion. Sugar, being more soluble than starch, will go through the membranes and get into the blood more readily than starch. After the food has undergone digestion in the mouth, it is swallowed, and passes through the gullet to the stomach. This gullet or œsophagus has a muscular coat which contracts around the food, forcing it onward and preventing it from returning.

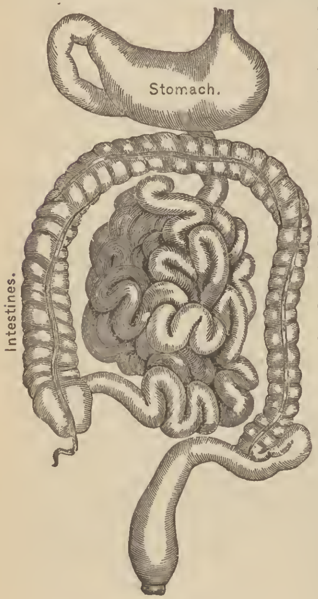

Fig. 36.
The Stomach and Intestines.

144. Digestion in the Stomach.—The stomach is a large bag or pouch situated in the upper part of the abdomen. In the walls of the stomach are numerous glands. Most of these glands secrete an *acid* fluid

which is called the *gastric juice*, or juice of the stomach. When the food reaches the stomach an active flow of this juice takes place. The food breaks up and dissolves more than it did in the mouth. This breaking-up process is partially due to the action of the gastric juice, and partly to a churning movement of the stomach. The saliva acts particularly on the starchy food. The gastric juice acts most rapidly and strongly on nitrogenous or albuminoid substances, such as meats, eggs, etc. It is supposed also that some saliva flows down into the stomach, and acts upon such starchy food as may have escaped its action above. The food, after undergoing these processes in the stomach, becomes a soft, pulpy, grayish mass, which is often called *chyme*, from a Greek word meaning "juice." While the food is digesting in the stomach, it is prevented from escaping by two rings, one at the entrance and the other at the outlet of the stomach. The ring at the outlet of the stomach, at the end which opens into the intestines, is called the *pylorus*, this word meaning "gate-keeper." It guards the gate from the stomach to the intestines.

145. Digestion in the Small Intestine.—As digestion in the stomach is completed, the pylorus relaxes, and allows the food to pass into the *small intestine*, a tube much twisted upon itself and about twenty-five feet long. In the walls of the small intestine are little glands which secrete an alkaline fluid, the *intestinal juice*. The intestinal juice keeps the food-pulp moist, and probably helps to remove an excess of acidity. Stretching across the abdomen, behind the stomach, is

a long, thin gland, the *pancreas* or *sweet-bread.* It secretes the *pancreatic juice*, which is poured by a duct into the small intestine near the stomach. This juice acts strongly upon the fats and oils of the food. Like salivá, it also has some power of converting starch into sugar, and acts upon nitrogenous food, but not with the same energy as gastric juice. Still another digestive juice, and a very important one, acts upon the food-pulp in the small intestine. This is a greenish-yellow liquid, called *bile.* It is secreted by the *liver*, the largest gland in the body, which is situated in the upper part of the right side of the abdomen. A duct or canal from the liver unites with the duct from the pancreas, and the pancreatic juice and bile are poured into the small intestine at the same place. The bile, like the pancreatic juice, acts particularly upon the fats and oils, and to some extent upon starchy food. Sweet oil and water will not mix well, but if they are shaken up with a little pancreatic juice and bile a uniform creamy mixture is produced. A similar effect is brought about by the action of pancreatic juice and bile upon the food in the small intestine.

146. Chyle.—The food, which left the stomach as chyme, after it has been acted upon by the intestinal juice, the pancreatic juice, and the bile, becomes converted into a thick, milky fluid which is called *chyle*, a name derived from a Greek word meaning "juice." The nutritious portions of the food are now ready to be taken into the blood.

147. Absorption.—Absorption is the process by

which substances are taken up and carried into the blood. Absorption is performed chiefly by two sets of vessels, (1) the *lacteals* or *lymphatics*, and (2) the *blood-vessels*.

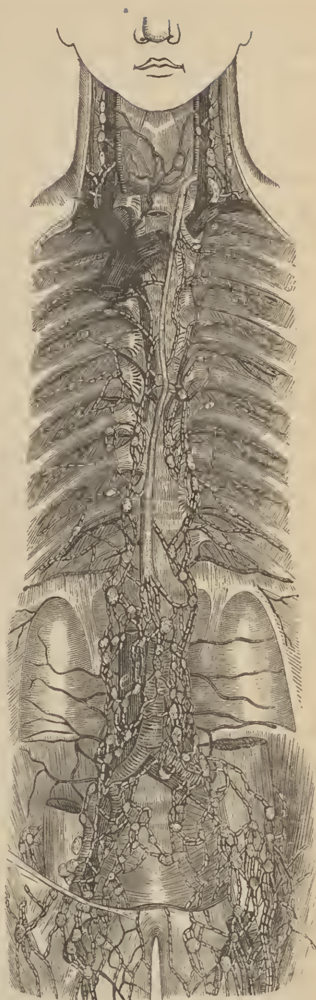

Fig. 37.
The Thoracic Duct and Lymphatics.

148. Lacteals.—The mucous or lining coat of the small intestine is covered with little projections or eminences called *villi*, from the Latin word *villus*, which means a "tuft of hair." In these villi minute tubes called *lacteals*, from *lac*, "milk," terminate. Thousands of these little pipes open into the intestines by way of the villi. They absorb from the creamy mass which is passing through the intestine what is needed to strengthen the blood.

149. The Thoracic Duct.—Leaving the intestine, the lacteals pass through numerous glands in the abdomen, and then

come together into one common duct called the *thoracic duct*, which is a feeding-pipe to the blood. This duct, which is about as large as a goose-quill, and eighteen to twenty inches long, passes upward through the abdomen and chest in front of the backbone. It is called the *thoracic* duct because its course is chiefly in the back part of the chest or thorax. It pours its contents into a big vein a little above the heart.

150. Lymphatics.—The lacteals are a part of a system of vessels called *lymphatics*. These lymphatics are tubes or vessels distinct from arteries, veins, and capillaries. They usually run along near the veins. They do not start, like the blood-vessels, from a great pumping heart; but they spring up here and there all over the body, uniting from time to time to form larger vessels. They carry a colorless fluid called *lymph*. The arteries and capillaries sometimes convey to the tissues more nutritive material than the tissues can at the time use. The lymphatics take up this surplus, but valuable, material; and thus keep it from doing harm or going to waste. They finally join with the lacteals to empty into the thoracic duct. Along the course of the lymphatics are little roundish or flattened bodies called *lymphatic glands*. When one has a cold, the lymphatic glands near the surface sometimes swell and become hard lumps.

151. Absorption Directly into the Blood.—Some things get into the blood from many places besides through the lacteals and lymphatics. Sugar, for instance, may pass into blood-vessels almost anywhere along the alimentary canal, because it dissolves so

readily and thoroughly. Water also, which is a very necessary part of our food, can slip into the blood almost anywhere. Little thin-walled blood-vessels, which are in the villi, take up some of the chyle.

152. The Large Intestine.—The last portion of the alimentary canal is the *large intestine.* It is from two to two and a half inches wide and about five feet long. Some things which are taken into the alimentary canal as food and drink are not made use of at all; they cannot be or are not digested and taken up so as finally to enter the blood. These pass off by way of this large intestine. Water is certainly absorbed by the large intestine, and some digestion may go on in it, but mostly it acts as a channel and temporary receptacle for undigested matters, which are finally cast out.

SYLLABUS.

The organs of digestion consist of the different parts of the alimentary or food canal and the glands communicating with it.

The different parts of the alimentary canal are the mouth and throat, the gullet or œsophagus, the stomach, and the intestines.

Liquid food passes quickly, by way of mouth, throat, and gullet, to the stomach.

Solid or partly solid food is chewed by the teeth and acted upon by the secretions of the mouth.

The secretions of the mouth are a watery fluid poured out by little glands in the mucous membrane of the mouth, and a fluid called saliva, which is secreted by three pairs of large glands.

Saliva converts starch into sugar; and sugar, being more soluble than starch, will go through the membranes and get into the blood more readily than starch.

After the food has undergone digestion in the mouth, it is swallowed, and passes through the gullet, or œsophagus, to the stomach.

In the walls of the stomach are numerous glands, most of which secretes an acid fluid called the gastric juice.

The gastric juice acts particularly on nitrogenous or albuminoid substances, such as meat, eggs, etc.

While the food is digesting in the stomach, it is prevented from escaping by two rings, one at the entrance and the other at the outlet of the stomach, the latter being called the pylorus, or "gatekeeper."

The food passes from the stomach into the small intestine, in the walls of which are little glands which pour out an alkaline fluid, the intestinal juice. This juice keeps the food-pulp moist, and probably helps to remove an excess of acidity.

The pancreas, or sweet-bread, secretes the pancreatic juice, which is poured into the small intestine near the stomach.

The pancreatic juice acts strongly upon the fats and oils of the food, and to some extent upon starch and nitrogenous food.

A greenish-yellow liquid called bile is secreted by the liver, and poured into the small intestine at the same place as the pancreatic juice.

The bile also acts particularly on the fats and oils, but also has some power to digest starchy food.

The food which left the stomach as chyme, after it has been acted upon by the intestinal juice, the pancreatic juice, and the bile, becomes converted into a thick, milky fluid, which is called chyle.

Absorption, the process by which substances are taken into the blood, is performed either by lacteals or lymphatics, or by the blood-vessels themselves.

The mucous or lining coat of the small intestine is covered with little projections or villi, in which minute tubes called lacteals terminate.

The lacteals absorb from the chyle nutritious material for the blood.

After passing through numerous glands, the lacteals come together into the thoracic duct, which is a feeding-pipe to the blood.

The thoracic duct passes upwards, and pours its contents into a big vein a little above the heart.

The lacteals are a part of a system of vessels called lymphatics, which usually run along near the veins, and carry a colorless fluid called lymph.

The arteries and capillaries sometimes convey to the tissues more nutritive material than the tissues can at the time use. The lymphatics take up this surplus, but valuable, material.

The lymphatics finally join with the lacteals to empty into the thoracic duct. Along the course of the lymphatics are little roundish or flattened lymphatic glands.

Some substances, as sugar, water, some of the chyle, etc., are absorbed directly into the blood through thin-walled blood-vessels.

Water is certainly absorbed in the large intestine, and some digestion may go on in it, but mostly it acts as a channel and temporary receptacle for undigested matters, which are finally cast out.

Questions for Review.

What are the organs of digestion?

What is the alimentary or food canal?

How does it begin?

What is the gullet or œsophagus?

What are the parts of the alimentary canal in the abdomen?

What becomes of liquid food taken into the mouth?

What happens to solid or half-solid food in the mouth?

What glands are present in the mucous membrane of the mouth?

How many large glands pour their secretion into the mouth?

What is this secretion called?

What is the name of the largest of these glands?

Where is it situated?

What does the word parotid mean?

Where are the other two glands situated?

What peculiar property is possessed by saliva?

In what way is the turning of starch into sugar a useful process in digestion?

What becomes of food after it has undergone digestion in the mouth?

How is the food forced onward through the gullet or œsophagus?

What is the stomach? Where is it situated?

What are present in the walls of the stomach?

What do the glands of the stomach secrete?

What takes place when the food reaches the stomach?

To what two things is the breaking up and dissolving of the food in the stomach due?

On what class of food-stuffs does the gastric juice act most rapidly and strongly?

What does the food become after undergoing the digestive processes in the stomach?

How is food prevented from escaping from the stomach during digestion in the stomach?

What is the ring or valve at the outlet of the stomach called?

What glands are present in the walls of the small intestine?

What are the functions of the intestinal juice?

What long, thin gland is situated behind the stomach?

What is secreted by the pancreas?

Into what is the pancreatic juice poured?

Upon what does the pancreatic juice act most strongly?

Does the pancreatic juice act upon starch and upon nitrogenous food?

What is bile?

By what organ is bile secreted?

Into what part of the alimentary canal is bile poured?

Upon what does the bile particularly act?

Give an illustration to show the action of bile and pancreatic juice upon fats and oils.

What is chyle?

From what is the word chyle derived?

What is absorption?

By what two sets of vessels is it chiefly performed?

With what is the lining-coat of the small intestine covered?

What are the lacteals? What is their function?

What is the thoracic duct?

Of what system of vessels are the lacteals a part?

How do they usually run? What do they carry?

What is the function of the lymphatics?

Into what do the lymphatics empty?

What are found along the course of the lymphatics?

Name some substance absorbed directly into the blood.

What are the functions of the large intestine?

CHAPTER XIV.

BREATHING.

153. The Air we Breathe.—The air is composed chiefly of two gases, oxygen and nitrogen, elements which also enter largely into our food. Oxygen is the great life-supporter. An animal deprived of it would soon die. When a candle burns, the substances in it unite with the oxygen of the air, and thus its burning is supported. When a lighted candle is put under a jar containing air, it will burn for a while and then go out, because it has used up all the oxygen and left only nitrogen. Nitrogen is necessary to man, but not in the same way as oxygen. In the air it acts to dilute or weaken the oxygen. Pure oxygen would be too much of a good thing. A candle in pure oxygen burns very brightly, but it soon burns itself out; so life would soon burn out if we breathed pure oxygen.

154. The Blood Needs Oxygen.—The blood must have oxygen, and it gets most of what it needs from the air we breathe. The blood in the arteries generally is of a bright red hue. The pulmonary or lung arteries, however, which carry blood from the

right side of the heart to the lungs, contain dark blue or purple blood. The bright redness is due to the oxygen present. If air is kept out of the lungs of a living animal—by compressing the windpipe, for instance—the blood in the arteries will lose its redness; it will become dark, like venous blood. The oxygen attaches itself in some way to the red corpuscles of the blood. It can actually be pumped out of arterial blood.

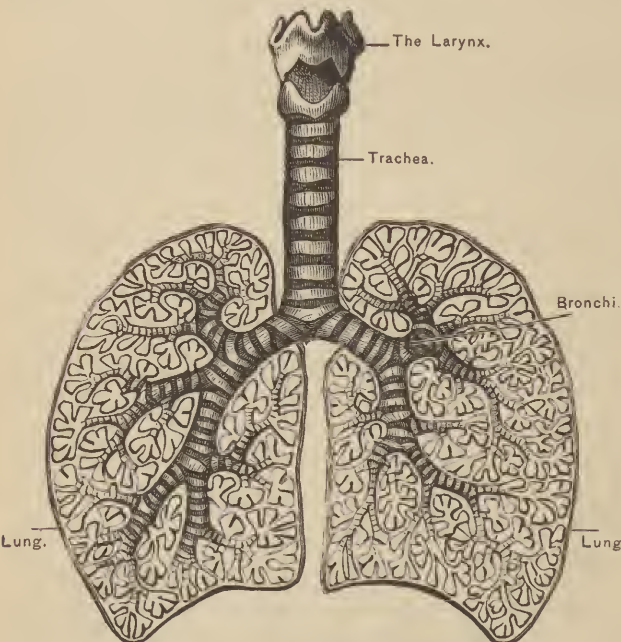

Fig. 38.—The Larynx, Trachea, Bronchi, and Lungs.

155. The Chief Organs for Breathing.—The chief organs for breathing are the *trachea* or windpipe,

which includes the *larynx* or voice-box, and the *lungs*. The nose, mouth, and throat also act as doorways and passage-ways for the air; and the diaphragm and certain muscles of the chest help in the act of breathing.

156. The Part Played by the Nose in Breathing.—The part played by the nose in breathing is by no means unimportant. The external air is first drawn through the nostrils. Inside the nose are thin plates of bones coiled upon themselves and covered with mucous membrane containing many blood-vessels. These are really "warming plates," like the plates of a stove.* The air passing over them is warmed before going to the lungs. Air should not be breathed in through the mouth, because it does not contain these "warming plates." Colds are sometimes caught by taking cold air into the chest through the mouth.

157. The Windpipe.—In the front of the neck is the trachea or windpipe, the large tube or pipe by means of which the air gets down into the lungs. It is firm and hard and made up of a number of rings of gristle placed one above the other. Behind it is the food-pipe or œsophagus. By running the fingers along the front of the neck, the rough windpipe can be felt through the skin.

158. The Voice-Box.—The windpipe widens out at its upper part to form a sort of box, which opens above into the throat. This box is called the *larynx*, a harsh-sounding word, which is derived from a Greek

* Fothergill's "Animal Physiology for Schools."

word meaning "to shout." The hard swelling seen on the outside of the upper portion of the neck, especially in thin people, and sometimes called "Adam's apple," is produced by the bulging outwards of the larynx. Mucous membrane, vessels, nerves, muscles, ligaments, and cartilage all go to make up this wonderful little box in which the voice is formed. Vessels supply it with blood; nerves serve to regulate its actions, and the muscles and ligaments are the agents for moving it and holding it together. Several cartilages, or pieces of gristle, are so arranged as to give the larynx a peculiar shape and fit it better to be a good voice-box.

159. The Vocal Chords.—Voice is made in the larynx with the help of the *vocal chords*. These "chords," as they are called, are not free bands or strings running across the cavity of the larynx. They are rather elastic lips or cushions fixed to the sides of the larynx, and having sharp free edges, between which is a narrow chink, the *glottis*, a Greek term which means the "mouth-piece of a flute." In ordinary breathing, a current of air passing through this chink produces no sound. When air is forced out of the lungs in voice-making, however, the vocal chords become tight, and are drawn in and made to shake or vibrate. This shaking or vibration makes the sound of the voice, just as sound comes from the tight fiddle-string when the bow sets it to vibrating. *Speech* is more than voice. It is the voice changed into sounds which have a meaning by the action of the throat, palate, tongue, teeth, and lips.

160. The Lid of the Larynx.—A little lid of gristle or cartilage is placed over the top of the larynx. It is just behind the tongue at the lower and front part of the throat. When it is down, it covers the glottis or chink between the vocal chords. It is called the *epiglottis*, from *epi*, which means "upon." When we breathe, this little lid lifts up; but when we swallow, it drops, and thus food or drink is prevented from getting into the voice-box and windpipe. Occasionally, especially if we talk or laugh at the same time that we are swallowing, the epiglottis does not shut down quickly enough, and food goes down the wrong way, causing us to cough or choke. Life has been lost in this way.

161. Bronchial Tubes and Air-Cells.—At the bottom of the windpipe, tubes or pipes branch to each side; from these others of smaller size proceed, and from the latter others still smaller. These are the *bronchi* or *bronchial tubes.* We have already spoken of the trachea as the windpipe; in the Greek, however, *bronchus* means "windpipe," and bronchus is an old term, now not often used, for the trachea or windpipe. The bronchi, then, are smaller windpipes, branches of the large windpipe. Some of the final bronchi are very small, but they are all hollow, just as much as are the trachea and large bronchi,

Fig. 39.—Air-Cells Magnified.

into which sticks might be thrust. Away out at the ends of the very finest bronchial tubes are little round bladders called *air-cells.* The lungs are made up largely of millions of these air-cells and fine bronchial tubes.

162. Inspiration and Expiration.—Air drawn in through the nose or mouth, or both, passes into the larynx and windpipe, and then into the bronchi and air-cells. This drawing of air into the lungs is *inspiration.* After it has done its part, the air is driven out again from the air-cells through bronchi, windpipe, larynx, throat, and mouth or nose, this being *expiration.* The whole process of breathing, including both inspiration and expiration, is called *respiration.* In the case of an adult in good health, this breathing in and breathing out takes place about seventeen or eighteen times every minute.

163. The Lungs and the Chest.—The lungs are within the cavity called the chest or thorax. It is an air-tight chamber. The diaphragm is its lower boundary. It has the sternum or breast-bone in its front and the back-bone or spine behind; and from back-bone to breast-bone run around the ribs. They are firmly attached to the breast-bone by gristle, but each rib is connected with the back-bone by a joint, which allows a little motion. Between the ribs are muscles; and when these muscles contract they pull up the ribs and cause the breast-bone to bulge forward, and thus more room is made for the lungs during inspiration.

164. The Diaphragm.—Between the chest and the

abdomen is the strong muscular partition, the *diaphragm.* The lungs come plump down upon this diaphragm. When they are empty, or nearly so, that is, just after expiration, this diaphragm arches upward, following them as they shrink. When air is drawn into the lungs, the air-cells everywhere fill out; room must be made; the diaphragm moves downwards before the swelling air-cells. The organs below the diaphragm—the liver, stomach, spleen, intestines, and kidneys—are also pushed downwards. The diaphragm being a muscle, its fibres contract during in-breathing, causing it, as a whole, to flatten and descend. When next air is breathed out, it is relaxed and at rest, and it is drawn up by the lungs, to which it closely clings.

165. Stationary Air and Tidal Air.—The lungs are not entirely emptied at each expiration or entirely filled at each inspiration. A certain amount of air, called *stationary air*, always remains in the air-cells of the lungs. Fresh air, or *tidal air* as it is called, is breathed in through the windpipe and bronchi, and this mixes with the stationary air of the air-cells and makes it purer. Breathing out or expiration then takes place, and some of the impure stationary air mixed with tidal air is driven out.

166. How the Oxygen of the Air gets into the Blood.—Around the millions of air-cells of the lungs is a network of millions of capillary blood-vessels. Pumped by the heart, the dark venous blood gathered from all parts of the body, rushes through the lung arteries into these little vessels. This purple blood is loaded with poisonous carbonic acid

gas, which leaks through the very thin walls of the blood-vessels and air-cells and mingles with the air, and is breathed out. At the same time oxygen from the air that has just been drawn into the lungs finds *its* way through cell-walls and vessel-walls into the blood. The blood gains oxygen and loses carbonic acid; the air gains carbonic acid and loses oxygen.

167. Oxidation.—In candles, lamps, and burning or combustible substances in general, are elements called carbon and hydrogen. The oxygen which is in the air unites with the carbon or hydrogen of the burning body, and this process is called *oxidation.* Heat is given out when bodies burn; a student's lamp, or even a candle, will give out a very perceptible amount of heat. One of the results of oxidation is the production of warmth or heat. Oxidation is constantly going on in the body. In the food which we eat are the same elements which are in the fuel burned in the stove or furnace, or in the candle, or the oil of the lamp. We breathe in the oxygen of the air. This oxygen gets into the blood and unites with the elements of food, which have also found their way into the blood. The food is oxidized. In this way *animal heat* is produced and life is sustained. Breathing is one of the chief means of keeping the body warm. Much of physiology relates to this subject of oxidation. Oxygen is breathed in by the lungs and filters into the blood; it is carried hither and thither by the blood; it unites in the blood or tissues with the elements of the food. Oxidation is going on when we move, feel, will, think, or carry out any other function.

Syllabus.

The air we breath is composed chiefly of oxygen and nitrogen, elements which also enter into our food.

Oxygen is the great life-supporter. Nitrogen acts to dilute or weaken the oxygen. Pure oxygen is too strong, and life would soon be burned out if we breathed it in the pure state.

The blood needs oxygen, and it gets most of what it needs from the air.

The bright red hue of arterial blood is due to the oxygen in it.

The oxygen attaches itself in some way to the red corpuscles of the blood.

The chief organs for breathing are the trachea or windpipe, which includes the larynx or voice-box, and the lungs.

Inside the nose are thin plates of bones coiled upon themselves, and covered with mucous membrane containing many blood-vessels. These are really "warming-plates." The air passing over them is warmed before going to the lungs.

Colds are caught by taking cold air into the chest through the mouth.

In the front of the neck is the trachea or windpipe, a large tube firm and hard, and made up of a number of rings of gristle placed one above the other. This is the tube or pipe by means of which the air gets down the lungs.

The windpipe widens out at its upper part to form the voice-box or larynx.

Several cartilages are so arranged as to give the larynx a peculiar shape, and fit it better to be a good voice-box.

Voice is made in the larynx with the help of the vocal chords, which are elastic lips or cushions fixed to the sides of the larynx, and having sharp, free edges, between which is a narrow chink, the glottis.

When air is forced out of the lungs in voice-making, the vocal chords become tight, and are drawn in and made to shake or vibrate.

Speech is voice changed into sounds which have a meaning by the action of the throat, palate, tongue, teeth, and lips.

A little lid of gristle or cartilage, called the epiglottis, is placed over the top of the larynx.

When we breathe, this little lid lifts up; but when we swallow, it drops, and thus food or drink is prevented from getting into the voice-box and windpipe.

Bronchi or bronchial tubes branch off from the trachea or windpipe.

Some of the final bronchi are very small, but they are all hollow.

Away out at the ends of the very finest bronchial tubes are little round bladders called air-cells. The lungs are made up largely of millions of these air-cells and bronchial tubes.

The drawing of air into the lungs is inspiration; driving it out again is expiration; the whole process of breathing is respiration.

An adult in good health breathes in and out about seventeen or eighteen times every minute.

The lungs are within the cavity called the chest or thorax, which is an air-tight chamber. The diaphragm is its lower boundary; it has the breast-bone in front, the back-bone behind, and from back-bone to breast-bone run around the ribs.

Between the ribs are muscles; and when these muscles contract, they pull up the ribs and cause the breast-bone to bulge forward, and thus more room is made for the lungs during inspiration.

Between the chest and abdomen is the diaphragm, upon which the lungs rest.

When the lungs are empty, or nearly so, the diaphragm arches upwards; when air is drawn into the lungs, the diaphragm moves downward before the swelling air-cells.

A certain amount of air, called stationary air, always remains in the air-cells of the lungs.

Fresh air, or tidal air, as it is called, is breathed in through the windpipe and bronchi, and this mixes with the stationary air and makes it purer.

When expiration takes place, some of the impure stationary air mixed with tidal air is driven out.

Pumped by the heart, the dark venous blood gathered from all parts of the body rushes through the lung arteries into the millions of capillary blood-vessels that surround the air-cells of the lungs.

This purple blood is loaded with carbonic acid gas, which leaks through the very thin walls of the blood-vessels and air-cells, and mingles with the air and is breathed out. At the same time, oxygen from the air finds its way through cell-walls and vessel-walls into the blood.

The blood gains oxygen and loses carbonic acid; the air gains carbonic acid and loses oxygen.

The oxygen which is in the air, unites with the carbon or hydrogen of burning bodies, and this process is called oxidation.

One of the results of oxidation is the production of warmth or heat.

Oxidation is constantly going on in the body.

In the food which we eat are the same elements which are in the fuel burned in the stove or furnace, or in the candle, or in the oil of the lamp.

The oxygen of the air gets into blood and unites with the elements of the food which have also found their way into the blood.

The food is oxidized; and in this way animal heat is produced and life is sustained.

Breathing is one of the chief means of keeping the body warm.

Much of physiology relates to this subject of oxidation.

Oxidation is going on when we move, feel, will, think, or carry out any other function.

Questions for Review.

Of what is the air composed?
Which constituent of the air is the great life-supporter?
How is the burning of a candle supported?
Why does a lighted candle put under a jar go out?
How does the nitrogen act?
Where does the blood get the oxygen which it needs?
What in general is the color of blood in the arteries?
What arteries alone contain dark blue or purple blood?
To what is the bright redness of arterial blood due?
How can the blood in arteries be made to turn dark?
To what in the blood is the oxygen attached?
What are the chief organs for breathing?
What part is played by the nose in breathing?
What "warming plates" are found inside of the nose?
Why should air be breathed into the mouth?
How are colds often caught?
Where and what is the trachea or windpipe?
What is the larynx? Describe its structure.
How is the voice made in the larynx?

What are the vocal chords?

What is the glottis?

What happens to the vocal chords in voice-making?

What is placed over the top of the larynx?

What is the lid of the larynx called, and why?

What happens to the epiglottis when we breathe?

What occurs when we swallow?

What accidents sometimes happen from talking or laughing at the same time that we are swallowing?

What are the bronchial tubes?

What is the meaning of the word bronchus?

What are found away out at the ends of the very finest bronchial tubes?

Of what are the lungs largely composed?

What is the process of inspiration?

What is expiration?

What is the whole process of breathing called?

How often does breathing in and breathing out take place in a healthy adult?

Describe the chest or thorax.

What is the action of the muscles situated between the ribs?

What is the diaphragm?

How are the lungs placed with reference to the diaphragm just after expiration?

What happens to the diaphragm when air is drawn into the lungs, and the air-cells everywhere expanded?

Are the lungs entirely emptied at each expiration?

Are the lungs entirely filled at each inspiration?

What is the air that always remains in the air-cells called?

What is the air breathed in at each inspiration called?

What net-work surrounds the air-cells of the lungs?

Describe the manner in which the venous blood gets into the capillaries of the lungs.

With what is the purple venous blood loaded?

What becomes of the carbonic acid gas?

At the same time that carbonic acid leaves, how does oxygen enter the lungs?

What does the blood gain? What does it lose?

What does the air gain? What does it lose?

What elements are found in burning or combustible substances?

What is oxidation?
What is given out when bodies burn?
What is one of the results of oxidation?
What is constantly going on in the body?
What elements are found in the food which we eat?
How is animal heat produced?
What is one of the chief means of keeping the body warm?
To what subject does much of physiology relate?

CHAPTER XV.

THE AIR AND HEALTH.

168. Pure Air and Its Relation to Health.— Pure air is essential to health; the blood calls for enough of it to give a full supply of oxygen. In the last Chapter, we learned that the lungs were never entirely emptied at expiration, nor filled at inspiration, but that a certain amount of stationary air always remained. This stationary air in the lungs needs to be constantly changed and renewed by fresh or tidal air, that it may be kept pure. The stationary air has been estimated at two hundred and fifty cubic inches; and the tidal air, which comes in at each breath, at twenty-six cubic inches. The tidal air is, therefore, continually renewing and purifying the stationary air. Sickness, and other evils, result from an imperfect supply of pure air, or from a supply of impure air, to the lungs.

169. How the Air is kept Pure in Nature.— The open air is kept pure and wholesome by certain natural processes. It is washed by the dew and rain. The sun warms and dries it. Its supply of oxygen and carbonic acid is largely regulated by the vegetable world—by the gardens, fields, and forests. Oxygen is

given out by plants; carbonic acid is absorbed by them. Animals, on the other hand, give out carbonic acid, and absorb oxygen; and thus a proper balance is preserved. All gases have a tendency to spread or diffuse themselves in all directions; so that carbonic acid, oxygen, or nitrogen, will not collect in one place. This diffusive power helps to keep the air pure. The winds increase the diffusion.

170. How the Air may be Rendered Unwholesome.—The air may be rendered impure and unwholesome in various ways. The total amount of air supplied to a given space may be too small. Some of the ingredients of the air may be wanting or in excess. We have learned that the air is chiefly composed of oxygen and nitrogen; but, besides these, pure air also contains a nearly fixed amount of carbonic acid, and a variable amount of watery vapor. As the amount of carbonic acid may be influenced by many special causes, variations in the quantity of this gas often render the atmosphere impure. The temperature of the air may be too high or too low. The air may contain too much or too little moisture or watery vapor. Sometimes impurity in the form of dust, often unseen, is in the air. It is supposed that the dust of our rooms frequently contains the germs of disease. Exhalations from decaying animal or vegetable matters sometimes poison the air. The air of our houses, particularly of our city houses, is not infrequently rendered impure by sewer-gas, which escapes from the drain-pipes which are intended to carry off waste and foul matters.

171. Amount of Fresh Air Required for Health. —An individual should be supplied with two thousand cubic feet of fresh air per hour. It has been calculated that every man ought to have at least eight hundred cubic feet of space to himself, and that the atmosphere ought to have free access directly or indirectly to that space. A cubical room, a little more than nine feet in each of its dimensions, would give this amount of space. A little thought will show us how seldom this requirement is met in our homes, school-rooms, and public halls.

172. Air Spoiled by One Man's Breath.*—A man, by his breath, will spoil in twenty-four hours about three hundred and fifty cubic feet of air; as much, that is, as would be contained in a room a little more than seven feet square, with a ceiling seven feet high. Could all the carbonic acid exhaled by a man in that number of hours be collected, and its carbon extracted from it, the latter would be equal to half a pound or more of charcoal, besides the organic matter given off, whose amount is not easily estimated.

173. Excess of Carbonic Acid in the Air.—Sometimes the air contains too much carbonic acid. This poisonous gas is constantly being given off by the lungs in breathing. Decaying animal and vegetable matter and burning bodies also produce it. Too

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* *Our Homes*, by Henry Hartshorne, A.M., M.D. One of the series of *American Health Primers* edited by W. W. Keen, M.D., and published by Presley Blakiston, Philadelphia, 1880. Many valuable facts and ideas with reference to the air and ventilation have been obtained from this book.

many people should not be gathered together in a small or badly aired room, or carbonic acid will collect in large amounts, and cause depression and languor. In mines, carbonic acid, and other poisonous gases, sometimes form, which injure or cause the death of the miners.

174. Deadly Effects of Carbonic Acid.—Many striking illustrations might be given of the deadly effects of an excess of carbonic acid in the air. In Italy is a cave or grotto through which a man may pass without danger, but a dog on entering it is instantly suffocated. Carbonic acid gas is here constantly issuing from the earth, and, on account of its weight, accumulates at the bottom of the cavern, while the air above is comparatively pure. In the Island of Java is a "Valley of Poison," where the ground is covered with the skeletons of birds and animals which have been suffocated by carbonic acid, which is present in large quantities. In Italy, also, is the Lake of Avernus, surrounded on every side but one by steep and densely wooded hills. The word "Avernus" is derived from Greek words meaning "without birds." According to the story, birds flying over the lake are poisoned by carbonic acid, and fall dead into the water. The ancients believed that this lake was the entrance to the infernal regions. Carbonic acid gas is sometimes used to suffocate butterflies and other insects when it is desired to preserve their colors perfect. In some of our large cities it is used to kill the dogs at the pounds, death by this method being painless.

175. Terrible Results of Crowding.—When human beings are crowded together, they breathe not only the carbonic acid and impure matters exhaled by others, but also rebreathe their own impure exhalations. The blood is poisoned, and the effects are sometimes terrible. The story of the "Black Hole of Calcutta" is often told to illustrate this fact. During a war in India, in the hot month of June, 1756, one hundred and forty-six Englishmen were shut up in a little room which contained only two very narrow windows. In eight hours all but twenty-three died. A steamer was overtaken at sea by a storm; the captain ordered all the passengers below, and then fastened down the hatches to prevent the water from getting into the vessel. In six hours, seventy-two died of suffocation.

176. Diseases of the Lungs and Air-Passages.—That common form of indisposition or sickness called a "cold," is sometimes caught by breathing through the mouth instead of the nose. Cold air is thus taken directly into the lungs instead of being tempered by the "warming-plates" in the nose. Colds are taken in many other ways, however; as, by exposure, particularly when heated, to draughts of air; by remaining too long in wet clothes; or by an insufficient or excessive amount of clothing. *Croup*, an affection of the larynx and windpipe; *bronchitis*, an inflammation of the mucous membrane which lines the bronchial tubes; and *pneumonia*, or inflammation of the lungs, are some of the diseases which result from improper exposure to cold and dampness. Consumption, or

phthisis, that much dreaded chronic disease, which causes destruction of the lungs, is often induced by impure air. A life in the open air, with plenty of good food and sufficient exercise, are among the best means of warding off or treating this disease.

177. Clothing with Reference to the Lungs and Breathing.—Clothing should be so worn as to allow the lungs and chest full chance to expand, or sufficient air will not enter the lungs to purify the blood. In children especially, while the bones are soft and yielding, the clothing should not be too tight. The bony frame-work of the chest is by nature somewhat wider below than above. Tight-lacing turns this natural state of things around, causing deformity.

Syllabus.

Pure air is essential to health, because the blood calls for a full supply of oxygen.

Fresh or tidal air is continually renewing and purifying the stationary air.

The open air is kept pure and wholesome by certain natural processes. It is washed by the dew and rain; it is warmed and dried by the sun; the vegetable and animal world help to preserve the proper balance between oxygen and carbonic acid; and gases having a tendency to spread or diffuse themselves, too much of one gas will not collect in one place.

The total amount of air supplied to a given space may be too small, or some of its ingredients may be wanting or in excess.

Variations in the quantity of carbonic acid gas often render it impure.

The temperature of the air may be too high or too low.

The air may contain too much or too little moisture.

Dust, exhalations from decaying animal or vegetable matters, and sewer-gases, are other sources of impurity of the air.

An individual should be supplied with two thousand cubic feet of fresh air per hour. He ought to have at least eight hundred cubic feet of space to himself, and the atmosphere ought to have free access to this space.

In twenty-four hours, a man will spoil by his breath about three hundred and fifty cubic feet of air.

Sometimes the air contains too much carbonic acid.

Carbonic acid gas is constantly given off by the lungs in breathing; and decaying animal and vegetable matter and burning bodies also produce it.

In a small or badly-aired room, carbonic acid will collect in large amounts and cause depression and languor. In mines, it and other poisonous gases sometimes form.

When human beings are crowded together, they breathe not only the carbonic acid and impure matters exhaled by others, but also re-breathe their own impure exhalations.

A "cold" is sometimes caught by breathing through the mouth instead of the nose. Cold air is thus taken directly into the lungs, instead of being tempered by the "warming-plates" in the nose.

Colds are also taken by exposure to draughts of air, by remaining too long in wet clothes, or by an insufficient or excessive amount of clothing.

Croup, bronchitis, and pneumonia are some of the diseases which result from improper exposure to cold and dampness.

Consumption, or phthisis, is often induced by impure air. Life in the open air, with plenty of good food and sufficient exercise, are the best means of preventing or treating this disease.

Clothing should be so worn as to allow the lungs and chest full chance to expand.

Tight-lacing is injurious.

Questions for Review.

Why is pure air essential to health?

Why does the stationary air in the lungs need to be constantly changed and renewed?

To how much does this stationary air amount?

How much tidal air comes in at each breath?

What result from an imperfect supply of pure air?

How is the open air kept pure and wholesome?

By what is it washed? What warms and dries it?

How is its supply of oxygen and carbonic acid largely regulated?

What is given out by plants? What is absorbed by them?

What is given out by animals? What is absorbed by them?

What tendency have all gases?

What does the diffusive power of gases help to do?

How do the winds act?

Mention some of the methods by which the air may be rendered impure and unwholesome.

What is said of carbonic acid rendering the air impure?

What is said of temperature, moisture, dust, organic exhalations, and sewer-gas?

How much fresh air per hour should be supplied to an individual?

How many cubic feet of space should he have to himself?

How many cubic feet of air will a man spoil by his breath in twenty-four hours?

How much carbon could be extracted from the carbonic acid exhaled by a man in twenty-four hours?

Mention some of the ways in which an excess of carbonic acid originates.

Give some illustrations of the deadly effects of an excess of carbonic acid in the air.

Give some illustrations of the terrible results of crowding.

How are colds sometimes caught?

Name some diseases of the air-passages and lungs which result from improper exposure to cold and dampness.

How is consumption often induced?

What are among the best means of preventing or treating this disease?

How should clothing be worn?

What is said about tight-lacing?

CHAPTER XVI.

VENTILATION.

178. Ventilation.—The word ventilation is derived from the Latin, *ventus*, "air" or "wind." To "ventilate" a place literally is to "cause the air to pass through it." Ventilation is the process by which the air to be breathed is kept pure. The buildings in which we live, and the lungs with which we breathe, should always be kept well ventilated. The tidal air ventilates the stationary air of the lungs. When we speak of ventilation, however, we generally have reference to the processes employed to keep our houses, churches, school-rooms, and public halls supplied with pure air.

179. Objects to be Aimed at in Ventilation.—The objects to be aimed at in ventilation are: 1. To move uniformly through a building the required amount of pure, fresh air. 2. Duly to distribute this air to the different apartments in the house. 3. Properly to diffuse it in each room. 4. To remove the vitiated air from every room in the building. 5. To

warm the air sufficiently in winter. 6. To supply it with an appropriate amount of moisture.*

180. Natural Ventilation.—The term natural or accidental ventilation is applied to that ventilation which is brought about by the ordinary construction of our dwelling-houses and public buildings—chiefly by doors, windows, and open fireplaces. Doors and windows which can be opened and shut at pleasure answer very well in some seasons and climates. Open fireplaces, when constructed properly, are efficient aids to ventilation. A fireplace with a wide-throated chimney, and either a coal-grate or a wood-fire burning in it, seldom needs any inlets or outlets for ventilation besides the cracks which unintentionally exist in windows and doorways.

181. The Walls of Buildings Permeable to Air.—Natural ventilation is accomplished in part by the walls of our buildings, through which more or less air will find its way. Brick, sandstone, and mortar can be penetrated by the air. The air which passes through walls may not be felt, because currents of air moving at a rate less than about twenty inches a second are not sensibly perceived. A scientist, named Pettenkofer, devised a curious experiment to show how air penetrates through gravel. He half filled a glass cylinder with gravel, over which a wire netting was placed; in this a canary bird was put, over him another wire netting, and above that the cylinder was filled to the top with gravel. The bird lived all day without

* The facts in this and several succeeding paragraphs have been chiefly obtained from Dr. Hartshorne's book.

seeming to be incommoded for want of air. The warmth of its body induced a gentle ascending and descending current of air around it through the two layers of gravel, the upper one communicating with the atmosphere. Without such a movement to renew the air for it to breathe, it would have been fatally poisoned in a very few hours.

182. Artificial Ventilation.—Artificial ventilation is that which is afforded by special apparatus or arrangements. To admit pure air to a room, one of the simplest plans is the insertion of a piece of wood made to fit under the lower sash of a window raised a few inches. Air then enters upwards between the two sashes at their place of junction. Another arrangement * is to place a piece of cloth or paper on the lower ten or twelve inches of the window-frame, and then raise the lower sash more or less, according to the weather. To get an upward-directed draught, a good method is to fix an upward-sloping board about six or eight inches below the top of a window, and then let down the upper sash a few inches. To allow air to come in slowly and without draught, another plan is to remove a pane from a window, and in its place to introduce wire gauze, or a piece of zinc perforated with a number of small holes. An ingenious, but not complicated, apparatus is that known as Maine's elbow-tube ventilator, which consists of a board (made in two parts sliding on each other, so as to be adjusted to different windows) to be placed under a raised sash, but having passed through it two pipes

* Suggested by Dr. W. W. Keen, of Philadelphia.

or tubes, about six inches in diameter, each bent upward in an elbow—the top of each tube being open above, and supplied with a regulating valve.

183. Relation of Inlets to Outlets in Ventilating.—To ventilate a room thoroughly, it is necessary to have outlets as well as inlets for the air. For rooms warmed by heated air, various arrangements for allowing air to enter and pass out have been invented. Generally, warm air enters near or in the floor, and escapes above near or in the ceiling. The outlet may be situated at various points with reference to the inlet—sometimes directly above, sometimes on the opposite side of the room, sometimes in the middle of the ceiling, the inlet being at one end or side. One good plan for small rooms is to have a warm-air register near the floor on one side, and a ventilating outlet near the ceiling on the other side; another is to have two registers, one on each side of a room, the outlet being in the ceiling. In the northwestern part of Philadelphia several blocks of houses have been built with an improved arrangement for ventilation. Each house has an air-chamber between the roof and upper floor. Narrow openings for air are placed in the walls at the sides of this chamber; and a ventilator is placed between it and the room below. The outlet to the chamber is a ventilating-pipe in the roof.

184. Temperature of the Air in Living Rooms.—For a school-room or sitting-room a temperature of about 68° to 70° Fahrenheit is the best in our climate. For a workshop, gymnasium, or any room in which active exercise is being taken, a lower temperature

will be better. For a sick-chamber, a temperature above 70° may sometimes be desirable. Over-heated or unequally-heated rooms are injurious to health.

185. Moisture of the Air in Living-Rooms.—The air of a living room, to be healthy, should always contain a certain amount of moisture. Stoves and furnaces sometimes cause undue dryness of the atmosphere. The proportion of moisture or aqueous vapor in the atmosphere may vary greatly. The possible amount present depends largely on the temperature. The higher air is heated the more watery vapor it is able to contain. When the rooms of a house are kept at a high temperature by means of heated air, some special arrangements should be made to evaporate water in them. A shallow pan of water placed over a stove or near a register will answer. Many heaters are supplied with an evaporating pan, by means of which moisture is supposed to be supplied to a whole house; but this alone will not do, as different apartments may be heated unequally, and the degree of humidity, as just stated, varies with the temperature.

186. The Ventilation of School-Rooms and Public Buildings.—School-rooms, where growing children spend so many hours at their tasks, should be thoroughly ventilated. The mind cannot be bright when the air is impure. Good authority asserts that from one to two thousand cubic feet of pure air should be supplied hourly to every child confined in school, in order that perfect health may be sustained. Very much less than this is usually furnished. Too often

little or no attention is paid to ventilation; pupils become listless and stupid; and their health is undermined. Our churches, theatres, and public halls are equally neglected.

187. The Ventilation of Bedrooms.—Fresh air should not be excluded from bedrooms. Some people, believing night-air to be unhealthy, keep the rooms in which they sleep as close as possible; they try to shut out every breath of air as if it were poison. Unless a house is very loosely built, it is better, as a rule, to open the windows of a sleeping-room a little, even in cold weather; although most people cannot stand to have a draught of air blowing directly upon them while asleep. The old fashion of surrounding a bed with curtains, or putting it in a curtained recess, was a very bad one, but fortunately is now but little in vogue. The sleeper was thus compelled to breathe over and over again his own poisonous breath.

Syllabus.

Ventilation is the process by which the air to be breathed is kept pure.

The tidal air ventilates the stationary air of the lungs.

When we speak of ventilation, we generally have reference to the processes employed to keep our houses, churches, school-rooms, and public halls supplied with pure air.

The objects to be aimed at in ventilation are: 1. To move uniformly through a building the required amount of pure, fresh air. 2. Duly to distribute the air to the different apartments in the house. 3. Properly to diffuse it in each room. 4. To remove the vitiated air from every room in the building. 5. To warm the air sufficiently

in winter. 6. To supply it with an appropriate amount of moisture.

Natural or accidental ventilation is that brought about by the ordinary construction of our dwelling-houses and public buildings—chiefly by doors, windows, and open fireplaces.

Natural ventilation is accomplished in part by the walls of our buildings, through which more or less air finds it way.

Artificial ventilation is that which is afforded by special apparatus or arrangement.

In ventilating a room warmed by heated air, generally warm air enters near or in the floor, and escapes above near or in the ceiling.

The outlet may be situated at various points with reference to the inlet—directly above, on the opposite side of the room, in the middle of the ceiling, the inlet being at one end or side.

One good plan for small rooms is to have a warm-air register near the floor on one side, and a ventilating outlet near the ceiling on the other side. Another is to have two registers, one on each side of a room, the outlet being in the ceiling.

For a school-room or sitting-room, a temperature of about 68° to 70° F. is the best in our climate.

For a workshop, gymnasium, or any room in which active exercise is being taken, a temperature lower than 68° will be better.

For a sick-chamber, a temperature above 70° may sometimes be desirable.

Over-heated or unequally-heated rooms are injurious to health.

The air of a living-room, to be healthy, should always contain a certain amount of moisture.

The higher air is heated, the more watery vapor it is able to contain.

When the rooms of a house are kept at a high temperature by means of heated air, some special arrangements should be made to evaporate water in them.

School-rooms, churches, theatres, and other public buildings, should always be thoroughly ventilated.

Fresh air should not be excluded from bedrooms. It is better to open the windows of sleeping-rooms.

Surrounding a bed with curtains, or putting it in a curtained recess, is a bad fashion, because the sleeper is thus compelled to breathe over and over again his own poisonous breath.

Questions for Review.

From what is the word ventilation derived?

Define ventilation.

By what is the stationary air of the lungs ventilated?

When we speak of ventilation, to what do we generally refer?

What six objects should be aimed at in ventilation?

To what is the term natural or artificial ventilation applied?

How is natural ventilation usually accomplished?

What is said of doors, windows, and open fireplaces?

Does air penetrate the walls of our buildings?

At what rate must currents of air move in order to be sensibly perceived?

Describe an experiment to show how air penetrates through gravel.

What is artificial ventilation?

Mention some of the best methods of admitting air into a room.

Describe Maine's elbow-tube ventilator.

What is said of outlets for air?

In general, where does warm air enter, and where does it leave a room?

Mention some of the situations in which outlets may be placed with reference to inlets in ventilating.

Describe an improved arrangement for ventilating some houses recently built in Philadelphia.

What is the best temperature for a school-room or sitting-room?

What is the best temperature for a workshop or a gymnasium?

What temperature may sometimes be desirable for a sick-room?

What is said about moisture in the air of a living-room?

What is sometimes the effect of stoves and furnaces?

Upon what does the possible amount of moisture in the atmosphere largely depend?

When the rooms of a house are kept at a high temperature, what should be done to insure a proper amount of moisture?

How many cubic feet of air should be supplied hourly to every child in school?

Is proper attention paid to ventilation of school-rooms and public buildings?

Mention some facts about the ventilation of bedrooms.

CHAPTER XVII.

EXCRETION, OR GETTING RID OF WASTE MATTERS.

188. Wear and Waste.—The body is wearing and wasting, as well as growing and repairing, all the time. We eat and drink a number of times each day, and, besides, we are constantly breathing in oxygen, which is a real food to the blood. Food, as we have learned, makes the blood rich, and the blood feeds the tissues—bone, muscle, nerve, glands, etc. The blood is constantly building these tissues. The parts of the body are, however, always at work, and everything that works must wear and waste, so that tissues are as constantly breaking down as they are building. Our bodies are always being made and unmade. It is a curious fact that the blood, which is the chief agent in building the tissues, also receives the products of their wasting. It takes up the useless particles, and carries them to the organs which cast them out of the body.

189. Wasting and Destruction are not the Same.—The different parts of the body waste through the

process of oxidation, but they are not destroyed. They change into other forms. When a frame house burns, it disappears as a house and as wood, but in the smoke and in the ashes are the same elements which were in the wood at first, with the addition of the oxygen which was taken from the air during the burning. This is similar to what takes place in the body. Substances which the blood gets from the food are oxidized or burnt up; tissues also are oxidized; but their elements are not destroyed.

190. The Principal Waste-Products of the Body.—These waste-products of the body usually become in the blood either *water*, *carbonic acid*, or *urea*, with small quantities of certain *salts*. Water is composed of hydrogen and oxygen; carbonic acid, of carbon and oxygen; urea, of carbon, hydrogen, nitrogen, and oxygen; and most of the salts contain oxygen, metals, and such substances as sulphur and phosphorus. In our food and tissues we have carbon, hydrogen, nitrogen, oxygen, phosphorus, sulphur, etc.; in the air is all-important oxygen. It is in great measure through the process of oxidation—through other substances seizing oxygen or oxygen seizing them—that waste-products are formed.

191. Waste Water.—Water is taken into the body, or is formed there in many ways. Much is taken in by drinking, much in our solid food. Oxygen seizes hydrogen in many places where tissues are breaking up into their elements, and thus also water is formed.

192. Carbonic Acid.—The oxygen which is being constantly breathed in by the lungs goes, as we have learned, all through the body; the red corpuscles of the blood acting as oxygen-carriers. They carry the oxygen into the tissues, wherever it is needed. The tissues all contain carbon. In some way, not yet fully understood, this carbon unites with the oxygen; and carbonic acid gas is formed. The blood, if examined chemically, can be shown to contain this carbonic acid.

193. Urea.—Urea is a substance in some respects like ammonia or hartshorn, but more complicated in composition. Many tissues, such as muscle and nerve, contain nitrogen in large amounts. Urea results largely from the wasting of these nitrogenous tissues; but it is also partly derived from other tissues containing carbon and hydrogen. It also springs partly from the action of some of the fluids of the alimentary canal upon nitrogenous food. It is really produced by a partial oxidation—the same process of oxidation which gives carbonic and water, only the process does not go far enough for carbonic acid and water to be formed.

194. Excretion.—The process by which these waste-products of the body are taken from the blood and cast out of the system is called *excretion*, which means the "act of sifting out." The waste-products themselves are called *excretions*. Excretions differ from *secretions*, such as saliva, bile, gastric juice, and the like, in that the latter have a purpose to serve in the body, while the former are simply refuse and waste matters.

Excretion is carried on chiefly by the *skin*, the *lungs*, and the *kidneys*.

195. The Skin as an Organ of Excretion. In Chapter I. the skin was described as consisting of an outer very thin layer called the *epidermis*, and of an inner and thicker layer, the *dermis*, or true skin. Running through both epidermis and dermis is an open channel, the *sweat-duct*, which in the latter coils up into a knot. This knotted end of the tube is a *sweat-gland*, (Fig. 40.) It is surrounded by a mesh or network of thin-walled capillary blood-vessels. The sweat-glands, which are exceedingly numerous, excrete waste water from the system as sweat or perspiration. Some chemical salts, in very small quantity, are dissolved in the sweat or perspiration, which passes off by the skin. We are really sweating more or less all the time. Physiologists speak of two kinds of perspiration, *sensible* and *insensible*. Sensible perspiration is that which we can see and feel, the ordinary sweat; insensible perspiration is that which is going on without being seen. The reason it is not recognized is because it passes off as steam or vapor as soon as it is formed.

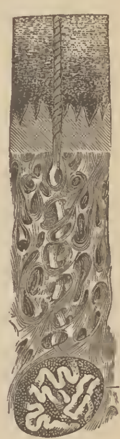


Fig. 40. Vertical Section of the Skin. (Highly magnified.)

196. The Lungs as Organs of Excretion.—The blood loaded with poisonous carbonic acid gas comes to the capillary vessels of the lungs. This gas finds its way through the thin walls of the vessels and air-cells and is breathed out. Much water also leaks

from the blood and is exhaled with the breath. Glass can be moistened by breathing on it.

197. The Kidneys as Organs of Excretion.—The kidneys are two in number, and are situated in the lower back part of the abdominal cavity, one on each side of the spinal column. Each kidney is between four and five inches long and from two to three inches in breadth. Blood-vessels enter the kidneys. The blood brought to the kidneys contains some of the waste-products of the tissues, particularly the urea. These waste matters, in the form of a liquid, are secreted or filtered from the blood into little tubes in the kidneys. This liquid, which consists mainly of urea dissolved in a very large quantity of water, with, however, small quantities of other animal and mineral substances, is finally collected by the body, and then cast out of the body.

198. Similarity of the Organs of Excretion.—The skin chiefly excretes water in the form of sweat, but small quantities of carbonic acid, and even of urea, are also passed off by it. The lungs are mainly concerned with casting out carbonic acid and water, but urea in small amount is also found in expired air. The kidneys have for their chief function the excretion of water and urea, but they also get rid of some carbonic acid. These three sets of organs, working together, prevent the machinery of the body from becoming clogged and choked with impurities. We should constantly aim to keep them in good working condition, in order that they may be able to carry out their functions.

Syllabus.

The body is wearing and wasting, as well as growing and repairing, all the time.

The parts of the body are always at work, and everything that works must wear and waste, so that the tissues are as constantly breaking down as they are building.

The blood takes up the useless particles, the products of the wasting tissues, and carries them to the organs which cast them out of the body.

Substances which the blood gets from the food are oxidized or burnt up; tissues also are oxidized; but their elements are not destroyed.

The waste-products of the body usually become in the blood either water, carbonic acid, or urea, with small quantities of certain salts.

Water is composed of hydrogen and oxygen; carbonic acid, of carbon and oxygen; urea, of carbon, hydrogen, nitrogen, and oxygen; and most of the salts contain oxygen, metals, and such substances as sulphur and phosphorus. In our food and tissues are these elements; in the air is oxygen. It is in great measure through other substances seizing oxygen or oxygen seizing them that waste-products are formed.

Much water is taken into the body by drinking, much in our solid food.

Oxygen seizes hydrogen in many places where tissues are breaking up into their elements, and thus also water is formed.

The red corpuscles of the blood carry the oxygen wherever it is needed. The tissues all contain carbon. This carbon unites with the oxygen, and carbonic acid gas is formed.

Urea results largely from the wasting of tissues which contain nitrogen in large amounts, such as muscle and nerve.

It also springs partly from the action of some of the fluids of the alimentary canal upon nitrogenous food.

Urea is really produced by a partial oxidation.

Excretion is the process by which the waste-products of the body are taken from the blood and cast out of the system. It is carried on chiefly by the skin, the lungs, and the kidneys.

Running through both the outer and inner layer of the skin is an open channel, the sweat-duct, which in the latter coils up into a knot, called the sweat-gland.

The sweat-gland is surrounded by a network of thin-walled capillary blood-vessels.

The sweat-glands, which are exceedingly numerous, excrete waste water from the system as sweat or perspiration. Some chemical salts, in very small quantity, are dissolved in the perspiration.

Sensible perspiration is that which we can see and feel; insensible perspiration is that which is going on without being seen, is passing off as steam or vapor as soon as it is formed.

Carbonic acid finds its way through the thin walls of the capillary vessels of the lungs into the air-cells, and is breathed out. Water also leaks from the blood and is exhaled with the breath.

The blood brought to the kidneys contains some of the waste-products of the tissues, particularly the urea; and these waste matters, in the form of a liquid, are finally cast out of the body.

The skin chiefly excretes water in the form of sweat, but small quantities of carbonic acid, and even of urea, are also passed off by it.

The lungs are mainly concerned with casting out carbonic acid and water, but urea in small amount is also found in expired air.

The kidneys have for their chief function the excretion of water and urea, but they also get rid of some carbonic acid.

The skin, the lungs, and the kidneys working together, prevent the machinery of the body from becoming clogged and choked with impurities.

Questions for Review.

What is happening to the body all the time?

What is the chief agent in building tissues?

What receives the products of the wasting of the tissues?

What does the blood do with the useless particles?

Through what process do the different parts of the body waste?

What happens when a frame house burns?

What substances are oxidized?

Are the tissues also oxidized?

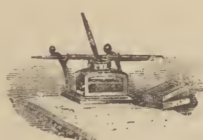
Are the elements of the food and of the tissues destroyed when oxidation takes place?

What are the principal waste-products of the body?

What is the composition of water, of carbonic acid, of urea, and of the salts?

What elements enter into our food and tissues?

What important element is in the air?
How is water taken into the body?
How is it formed in the body?
Describe the process by which carbonic acid is formed in the body.
What substance does urea resemble?
What tissues contain nitrogen in large amounts?
How is urea largely produced?
From what, also, does it partly spring?
What is the real nature of the process by which urea is produced?
Define excretion.
What is the difference between excretions and secretions?
What are the organs of excretions?
What channel runs through the skin?
What is the knotted end of the sweat-duct called?
What do the sweat-glands excrete?
What is sensible perspiration?
What is insensible perspiration?
What excretions are cast out by the lungs?
Describe the kidneys.
What waste matters are excreted by the kidneys?
Explain the similarity between the organs of excretion.
What do the three sets of excretory organs accomplish?



CHAPTER XVIII.

HINTS ON HYGIENE, ACCIDENTS, AND POISONS.

199. Rules of Simple Hygiene.*—The following rules of simple hygiene will be found useful:

Wash the whole body, at least twice in every week, either with cold or slightly warmed water, and rub thoroughly dry with a rough towel.

The least one can do, with any attention to cleanliness or health, is to sponge the face, chest, and back with water, and dry rub the rest of the body at least once every day.

For a thorough wash of the hands, use warm water, and before soaping them, steep them well in the water for a minute or two, rubbing them the while, then use soap and a nail-brush. End by holding the hands under a tap of cold water, and "give them a shower-bath:" it is refreshing and strengthening to the fingers; or dip them into cold water and rub them dry as quickly as possible.

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* These "rules of simple hygiene" are from *Hints and Remedies for the Treatment of Common Accidents and Diseases, and Rules of Simple Hygiene*, compiled by Dawson W. Turner, D.C.L.: Macmillan & Co., New York. The rules are given with omissions, additions, and changes in language and arrangement. Dr. Turner's book has been drawn upon for other material for the present chapter. We have also made use of a valuable little book by Dr. Charles W. Dulles, entitled *What to do First in Accidents or Poisoning*, published by Presley Blakiston, Philadelphia, 1880; and of a larger volume of *Plain Directions for Accidents and Poisons*, distributed by the Mutual Life Insurance Company of New York.

If possible, get that most cleansing thing, a hot bath, once a week; use plenty of soap, with a flannel, over the whole body, and scour with a pretty hard bath-brush; then soak for a few minutes, and come out "as clean as a new shilling."

Use a flesh-brush, or rough towel, on the skin once a day. The best time is at night.

Brush the teeth the last thing every night before going to bed, and comb and brush the hair the wrong way, or any way but the right way, so as to let the air in upon the head.

Rinse out the mouth, or, better still, brush the teeth after every meal.

Tooth-brushes cannot be too soft. Hard brushes make the gums recede from the teeth, and produce premature decay by causing the soft bone of the tooth to be exposed to the air, beyond the part of the tooth protected by the enamel.

Do not plaster down the hair with pomatum or pomade; the hair is meant to assist in carrying off perspiration, and should not be clogged with grease. No appreciable mischief results from oiling it occasionally; nor does sweet-oil do any harm to any part of the body, if it is rubbed into the skin before a fire, but, on the contrary, it does good, as it renders the limbs supple and more capable of strong muscular exertion.

Beware of drinking any very hot fluids. After fatigue and long fasts, hot fluids, only not too hot, are valuable, and a few mouthfuls, taken in such cases before beginning to eat, are useful, especially for elderly people.

Avoid much use of sweets, tarts, pastry, confectionery, and sugar.

All clothing, particularly that which is worn next to the skin, should be turned inside out before going to bed, and hung up to air above the level of the head.

Open the bed entirely in the morning, lifting the sheet and blanket so as to let the air get underneath; and leave the windows open top and bottom.

Never sit down to breakfast without first going out into the open air for a few minutes. Make the walk longer or shorter, according to health and strength.

If any one is ill with fever, or with any infectious disease, do not visit him the first thing in the morning before eating, but take a

mouthful of coffee or tea, and a crust of bread, before entering his bedroom.

In order to avoid infection, or any low fever, look sharp after all drains and cesspools. Keep them in good repair and working order, and flush all sewers and drains now and then with plenty of water. In a dry season pour a pailful or two of water, with about a quarter of a pint of carbolic acid in it, into all drains and cesspools every other day, to take away any bad smell. If carbolic acid cannot be had, use chloride of lime, or something of the same sort. Copperas (sulphate of iron) is a cheap but very efficient disinfecting agent. A handful of this salt thrown down the water-closet three or four times a week answers every purpose.

If troubled with cold feet at night, rub them well before getting into bed; and if that does not answer, sponge them with cold water, and, while drying them, rub the toes and ankles upwards, and not downwards. In case this plan fails, as it does sometimes, and the feet still remain cold, try putting them in a mustard foot-bath before stepping into bed, and put on a pair of thick, dry woollen socks directly afterwards. The socks can be removed as soon as the feet are warm. Feet that are constantly cold at night are never found in persons in the enjoyment of good health.

Avoid all hot and heavy suppers, unless desirous of an attack of nightmare. A so-called "severe tea" late at night is usually unwholesome. Never go to bed, however, with an entirely "empty stomach." This is often the cause of "insomnia," or sleeplessness, especially in elderly persons.

If troubled with sleeplessness, sponge the whole body before going to bed, and rub dry with a Turkish towel; use the dumb bells or any other gymnastic exercise, and jump into bed warm, and banish unpleasant thoughts.

Finally, try to keep a clear conscience, an even temper, a light heart, and a good digestion.

200. Asphyxia.—The word *asphyxia*, now commonly applied to cases of suspended animation or apparent death from various causes, is a term derived from the Greek, and really means an "absence of pulse." The lungs, as we have learned, convert the dark and

poisonous venous blood into life-renewing arterial blood. This change is effected through the pure tidal air which is breathed in by the lungs. In asphyxia, the supply of tidal air is in some way cut off. When the head is under water, as in drowning; when foul gases are inhaled, or when a foreign body stops up the air-passages, asphyxia may result. Death in such cases may be prevented by taking prompt measures that will insure the admission of abundance of fresh air into the lungs.

201. Apparent Drowning.—In apparent drowning, the body should be taken from the water as soon as possible, and turned over upon its face for a moment. A finger should be swept around in the mouth to bring away any mucus or other substances that may be present. The body should be laid out flat on the back, with something a few inches high under the shoulders. The tongue should be drawn well forward and held out of the mouth by means of a handkerchief, and the effort to secure artificial respiration begun as follows: Some one should place himself on his knees behind the patient's head, seize both arms near the elbows and sweep them around horizontally, away from the body and over the head till they meet above it, when a strong pull should be made upon them, and kept up two or three seconds. This effects an inspiration—fills the lungs with air, by drawing the ribs up and so enlarging the cavity of the chest. The second manœuvre consists simply in returning the arms to their former position alongside the chest, and then making firm pressure against the

lower ribs, so as to drive the air out of the chest and effect an act of expiration. This need occupy but a second of time. If this plan is regularly carried out, it will make about sixteen complete acts of respiration in a minute. It should be kept up for a long time, until a competent person has ascertained that the heart has ceased to beat. Warmth should be applied by heated flannels, or in any other convenient way; and a stimulant should be given as soon as it can be swallowed. A teaspoonful to a tablespoonful of whiskey or brandy should be given every few minutes, until a decided effect is produced. As natural respiration begins to be attempted, it should be aided as much as possible by timing the artificial to it. When resuscitation is accomplished, the person should be put in a warm bed, being carried carefully, with the head low, and a watch kept to see that the breathing does not suddenly stop.

202. Asphyxia from Noxious Gases. — Certain poisonous gases are given off during the burning of charcoal. Anthracite and bituminous coal, when burned in a close room, as a kitchen shut up for the night with an open stove of these burning coals, also give off noxious gases. Persons sleeping in such a room, unless awakened as the air becomes fouled, will be found senseless or dead soon after. Persons retiring at night may leave the gas "turned down;" the flame becomes extinguished, and enough gas escapes to poison the inmates of the room. Asphyxia, or suffocation, from these or other noxious gases, calls for removal to the open air, dashing with cold water, stimulants, and

the employment of artificial respiration, as described in speaking of apparent drowning. Risk of poisoning from these sources can be obviated by leaving the window down from the top, and raising it a few inches from the bottom, thus securing proper ventilation.

203. Heatstroke or Heat-Exhaustion.—Intense heat, either from the sun or from artificial sources, produces one of two conditions, either heatstroke or heat-exhaustion. Heatstroke, sometimes called sunstroke, appears to be decidedly favored by intemperance, want of acclimatization, and debility. The skin is hot and dry, the pulse rapid, and the patient unconscious. The person attacked should at once be carried to a cool, airy spot. Unnecessary bystanders must be kept at a distance, as the person in this, as in every other accident, needs all the pure air he can get. The clothing should be removed, and the patient placed on his back, with the head raised a couple of inches by a folded garment. The entire body, particularly the head and chest, should be dashed with cold water in profusion, should be rubbed with ice, and ice should be applied to the head and spine. Physicians usually inject quinine beneath the skin. For heat-exhaustion, in which the body is cool, the skin moist, the pulse small, and the muscles relaxed, or sometimes convulsed, a few drops of laudanum in a tablespoonful of whiskey or brandy will be very useful. In these cases it has been found by physicians that morphia injected beneath the skin gives immediate relief.

204. Fainting.—Persons sometimes fall in what is called a swoon or faint. An attack of fainting is ordi-

narily not dangerous to life; although sometimes attacks which look like a simple faint are the result of serious disease of the heart or brain. The fainting person suddenly becomes pale, loses consciousness, and usually falls, the pulsations of the heart and the movements of breathing becoming diminished. In a faint, the brain is commonly deprived temporarily of its proper supply of blood. The individual in the faint should be carefully placed flat on the back, and the clothing loosened. In some cases it is well to raise the body and limbs a little above the level of the head; especially is this procedure called for when unconsciousness has been produced by a blow or anything giving rise to a decided shock. In this way the circulation will be given the best possible chance to right itself. Sprinkling cold water on the face, and applying ammonia water to the nostrils and warmth to the extremities and over the stomach, will also assist in bringing about reaction.

205. Convulsions.—In convulsions, or "fits," which are usually epileptic, movements calculated to injure the person must be controlled. It is useless to struggle against such as will do no injury; they had better be simply regulated, and no attempt made to entirely prevent them; but a folded towel or a piece of soft wood may be, when possible, thrust between the teeth, to prevent the usual biting of the tongue. If the clothing constricts any portion of the body sufficiently to interfere with the breathing, or the circulation of the blood, it should be loosened. When the height of the convulsion is passed, rest in

the flat position, quiet, and sometimes a moderate stimulation, may be required.

206. Burns or Scalds.—When clothes are on fire, the wearer must not run about, but should be made to lie down, and should be covered with a rug, or carpet, or shawl, or coat—anything that will exclude the air and smother the flame. Afterward, the burned part must be disturbed as little as possible, and the patient may be enveloped in lint soaked in a mixture of equal parts of linseed-oil and lime-water. Stimulants and anodynes should be administered. Medical advice should always be taken in such grave circumstances. Slight burns are best treated by applying a cloth soaked in a strong solution of baking soda—the bicarbonate of soda. Linseed-oil and lime-water is also a good application for such burns.

207. Sprains.—In a sprain the joint is twisted, and its ligaments are stretched or even torn. Sprains most frequently occur at the wrist and ankle-joints. The injury is rapidly followed by inflammation of the joint and adjacent parts, with great pain and often swelling. Sprains must be treated by rest, and heat or cold, as is best suited to each case. Sprains of the finger or wrist usually require cold and moist applications. A lotion of lead-water and laudanum is useful to allay inflammation. To promote absorption of any inflammatory products that may be left, painting over the joint with tincture of iodine, and rubbing and kneading, are useful.

208. Foreign Bodies in the Eye.—Particles of cinder, dust, or fragments of metal often get into the

eye and cause trouble. A good plan is to hold a knitting-needle, or thin lead-pencil, over the upper lid; then, while the person looks, or turns his eye downward, seize the lashes of that lid by the fingers of the disengaged hand, and gently turn the lid upward and backward over the needle or pencil. Usually the intruder can be seen and removed. Should the foreign body be imbedded in the eyeball or the eyelid, the case should be left to a surgeon. The foreign body often cannot be seen, but the person assures us that he feels it. Often he does not really feel the body, but the roughness left by it. In such a case, or even if the body has been seen and removed, a soothing application to the injury is as useful as the same thing applied to a wound of the hand. A good eyewash is made by dissolving eight grains of borax in a mixture of one-half ounce of infusion of sassafras, and one ounce and a half of camphor water. Never draw a handkerchief, or anything else, between the eyelids to remove a foreign body. We know of one case in which the sight was almost destroyed as the result of an inflammation set up by dragging the foreign body across the eyeball in this way. In fact, it is better not to meddle with the eye at all if a physician can possibly be secured.

209. Insects in the Ear.—Insects sometimes get into the ear. The best way of getting them out is to fill the cavity of the ear with sweet-oil or glycerine. It drowns the animal by closing up its breathing pores, and in a short time it floats to the surface of the fluid used. The tube of the ear is somewhat curved, and

when straightened by catching hold of the upper tip, and gently pulling it upward toward the crown of the head, the liquid flows in more readily.

210. Foreign Bodies in the Throat.—Foreign bodies sometimes get lodged in the throat. A crust of bread, or a bone, or some other object, may be lodged where it can be reached, when it is best removed with the fingers. Forceps may be used if at hand. If a piece of food is caught in the windpipe, owing to the epiglottis not shutting down quickly enough, usually it will be coughed out. If, however, it remains, an effort should be made to remove it with the fingers, and a physician should be called at once. Tickling the ear with a feather, or slapping the back with the hand, will sometimes excite coughing.

211. Foreign Bodies in the Nose.—If a foreign body, such as a pebble or grain of coffee, gets into a nostril, the first thing to do is to try to expel it by gently blowing the nose. The nose should never be blown violently, for this may set up inflammation of the middle ear, and greatly impair the hearing. If ordinary blowing does not succeed, the child should be made to take a full breath; then closing the other nostril and the mouth, when the lungs empty themselves by expiration the foreign body may be driven out of the nostril. If it should not be expelled by either of these methods, a physician must be called.

212. Bleeding from the Nose.—Bleeding from the nose can usually be stopped by application of cold water or ice to the outside and inside of the nostrils;

but sometimes the bleeding is profuse and obstinate. Vinegar, or a strong solution of alum in warm water, can be snuffed up the nose; or cotton, soaked in vinegar or alum-water, may be used as a plug. The bleeding may frequently be stopped by pressing the finger with moderate firmness over the upper portion of the upper lip to the outer side of the nostril from which the blood proceeds. A small, hard roll of paper passed well up beneath the upper lip in the same situation is often sufficient. Water as hot as can be borne, carried into the bleeding nostril by gentle efforts at inspiration, while the mouth and opposite nostril are closed, in many cases is promptly effectual. Do not blow the nose during or soon after the bleeding; keep the mouth shut, and breathe through the nose.

213. Bleeding from Wounds.—Capillary hemorrhage follows every cut. The color of the blood is bright red; the flow is generally slow and not very considerable. It usually stops of itself. If it does not, cold water, ice, or vinegar may be applied. For oozing from a large raw surface, a towel may be folded, dipped in water as hot as the hand can bear, lightly squeezed, so as not to drip, and laid upon the bleeding surface. Bleeding from the veins is also generally slow and steady, the blood being of a darker color. The application of cold and continuous pressure upon and below the wound are the proper methods of treatment. Hemorrhage from the arteries is very dangerous. In such a case the blood is bright red, and spurts in a stream or leaps in jets from the divided vessel. For wounds of the arteries of the hand, raising the hand above

the head, and making firm pressure with the thumbs just above and in front of the wrist, will usually stop the bleeding. If this fails, and for wounds below the elbow, first grasp the upper part of the arm with both hands and squeeze as hard as possible; then let some one make a thick, hard knot, as big as an egg, in the middle of a handkerchief, place it over the middle of the front of the arm, immediately above the elbow, tie the ends tight at the back, and bend the forearm up so as to press hard against the knot. This, if successfully done, will obstruct the main bloodvessel, which in this place lies in the middle line of the bend of the elbow. For wounds in the upper arm, a knot as big as a fist may be made in any piece of cloth, and shoved hard up into the armpit, and the elbow then brought straight down and held firmly against the side of the chest. The principal object is to obstruct the bloodvessel above the cut, and this can be effected by a knot placed, in the several cases, in front of the bend of the elbow, in the armpit; or for the lower extremity, behind the bend of the knee, or just below the groin, against which the nearest part of the limb is to be firmly pressed.

214. Poisons in General.—Some knowledge of poisons and of the substances used to counteract their effects (antidotes) will frequently save valuable lives. Many poisonous substances are in common use as medicines, for domestic purposes, or in the mechanic arts. Bottles or packages containing poisons should be carefully labelled and kept out of the way of children. When a poison has been swallowed, it is a good plan

to empty the stomach as speedily as possible. Vomiting can be effected by several methods. Simple warm water, given cup after cup, is often all that will be necessary. A tablespoonful of ground mustard or of common salt can be mixed with a large tumblerful of water, and this can be given and repeated several times until vomiting is produced. After vomiting has commenced, warm water, flaxseed tea, or gum-arabic water may be given to continue the vomiting and soothe the stomach. Fat, oils, milk, raw eggs beaten up—all in moderate quantities—are especially valuable when the poison has been of an irritant character. If the sufferer is much depressed or cold, some stimulant, as hot tea, hot coffee, brandy, whiskey, or wine, may be administered. Warmth should also be applied.

215. Different Classes of Poisons.—Poisons can be arranged into different classes: some are acids, some are alkalies; some are irritant mineral poisons, such as arsenic, sugar of lead, corrosive sublimate, tartar emetic, phosphorus, and lunar caustic; and some are special vegetable poisons, such as strychnia, opium, aconite, Jamestown weed, hemlock, nightshade, toadstool, tobacco, etc., etc. Certain general principles of treatment apply for all the poisons of each special class.

Acid Poisons.—The strong acids, such as sulphuric, nitric, and muriatic, are violent poisons, and yet are in common use, particularly in certain mechanical pursuits. The proper treatment for poisoning by any of these mineral acids is to give an alkali, as magnesia, lime, baking soda, whitewash, chalk, hartshorn mixed with plenty of water, etc. Vomiting should be provoked and bland liquids given. A little calcined magnesia in a case like this might be the means of saving a life. For oxalic acid, lime-water, chalk, white-

wash, or even plaster crushed and stirred up in water, will answer. *Carbolic Acid* is a substance now much used as a medicine and as a disinfectant, and cases of poisoning from it occasionally occur. This odor, which is like that of creasote, should serve to put a person on guard with reference to the substance. Strong carbolic acid will corrode or burn the skin. If it should be accidentally poured or spilled upon the skin, the burn produced should be treated with cooling lotions, oils, or salves, as other burns. Taken internally, carbolic acid is a very poisonous substance. Besides the caustic or burning effect upon the mucous membrane of the mouth, throat, and alimentary canal, it exerts a peculiar effect upon the system, which shows itself by nausea or vomiting, sweating, lividity, labored breathing, feeble pulse, tremor, and paralysis. A good antidote for carbolic acid is the common Epsom salt or sulphate of magnesium. In case of poisoning by carbolic acid, therefore, after having tried to provoke vomiting, and after giving draughts of oil or milk to relieve the burning of the mouth and throat, a large quantity of Epsom salt should be dissolved in water and given freely to the sufferer. To accomplish the purpose for which it is given, the antidote must be administered early and in large amounts.

Alkaline Poisons.—The strong alkalies are ammonia, or hartshorn, potash and soda, the latter two usually dissolved in water, the solution being generally called *lye*. Liniments sometimes contain ammonia, and are swallowed by mistake. Alkalies burn skin or mucous membrane rapidly and severely. The proper antidotes are mild acids, such as lemon juice or vinegar, which should be given in large quantity.

Arsenic.—When arsenic has been taken, an antidote must be administered immediately, if life is to be saved. It can be obtained in the following manner: Take tincture of iron or Monsel's solution, and into it pour ammonia-water or some strong alkali; a precipitate will be obtained, which should be strained and given immediately, with large doses of calcined magnesia. Vomiting should be provoked or continued, and a dose of castor-oil should be given. Dialyzed iron, a preparation which can now be obtained from any drug-store, may be given in tablespoonful doses, following each dose by a tablespoonful of common salt in a teacupful of water. Paris green is an arsenical preparation.

Sugar of Lead.—For poisoning by sugar of lead, to produce vomiting, give Epsom salt, milk, eggs, and castor-oil.

Corrosive Sublimate.—Corrosive sublimate dissolved in whiskey is an article frequently used to destroy vermin. If it should be swallowed by mistake, the stomach should be emptied by means of mild emetics; plenty of eggs and flour in soothing drinks should be given, and, later, sweet-oil. To relieve pain, and strengthen, opium in some form, and whiskey might also be required.

Tartar Emetic.—By mistake, an overdose of tartar emetic may be administered. A strong decoction of good green tea, or oak bark, if taken soon, will change the tartar emetic into a harmless compound.

Phosphorus.—Phosphorus is sometimes sucked from matches by children. It is a poison which acts slowly, and affords ample time for securing medical advice; but five-grain doses of sulphate of copper, dissolved in water, may be given at intervals of ten minutes, until vomiting comes on. Then a dose of magnesia should be administered, but no fat oil.

Lunar Caustic.—Lunar caustic is sometimes swallowed. The antidote for this is a very strong solution of salt and water given again and again; and vomiting should be provoked until the vomited matters cease to have a look like thin milk.

Copper.—Vessels of copper often give rise to poisoning. Though the metal undergoes but little change in a dry atmosphere, it is rusted if acids be present, and its surface becomes covered with a green substance—one of the salts of copper,—a poisonous compound. It has sometimes happened that a mother has, for want of knowledge, thus poisoned her family. For poisoning with copper, milk, eggs, or baking soda should be given.

Nux Vomica, or Strychnia.—For poisoning by nux vomica, or strychnia, use emetics or stomach-pump; chloral hydrate and bromide of potassium in large doses; chloroform to relieve spasm of glottis; stimulants, if needed; and morphia in one-grain doses, repeated if necessary.

Opium.—Opium, and its preparations, such as *laudanum*, *paregoric*, *black drop*, many quack-medicines sold as soothing-syrups, etc., when taken in poisonous amounts, cause deep sleep, with narrowing of the pupil of the eye to a small circle, which does not

enlarge in the dark. Emetics must be used promptly and persistently, and frequent vomiting produced. Strong coffee must be freely given as a stimulant. So long as the breathing does not fall below ten to the minute, there is no *immediate* danger of death; but opium is a treacherous poison, and requires all the skill that can be obtained to combat it. The important matter is to keep up the breathing. If an electrical battery can be obtained and used, it is the best thing that can be done. The next is to lay the patient upon a lounge and slap his skin with the back of a broad brush or with a slipper. This is all the rousing that is necessary, so long as the breathing keeps above ten to the minute. Should it fall below this, or if the breathing should cease, artificial respiration should be employed.

Special Vegetable Poisons.—*Aconite, hemlock, deadly nightshade*, the *Jamestown weed, monk's-hood, toadstools*, and *tobacco*, in poisonous doses, all produce deep depression, and persons poisoned by them must be treated with vomiting, followed by stimulation and warmth.

Syllabus.

Asphyxia is a term applied to cases of suspended animation or apparent death, caused by the supply of tidal air being in some way cut off from the lungs.

When the head is under water, as in drowning, when foul gases are inhaled, or when a foreign body stops up the air-passages, asphyxia may result.

In apparent drowning, the body should be taken from the water as soon as possible, and turned over upon its face for a moment; a finger should be swept around in the mouth; the body should be laid on the back, with something a few inches high under the shoulders; the tongue should be drawn well forward and held out of the mouth, and the effort to secure artificial respiration should be attempted.

When artificial respiration has been accomplished, warmth should be applied and stimulants given.

Asphyxia is sometimes produced by noxious gases, and calls for removal to the open air, dashing with cold water, stimulants, and the employment of artificial respiration.

Intense heat sometimes produces heat-stroke or sun-stroke, in which the skin is hot and dry, the pulse rapid, and the patient unconscious.

The person attacked with heat-stroke should be carried to a cool, airy spot, his clothing should be removed, and his body should be dashed with cold water or rubbed with ice.

Heat-exhaustion, also, results sometimes from intense heat. The body is cool, the skin moist, the pulse small, and the muscles relaxed or sometimes convulsed. A few drops of laudanum in a tablespoonful of whiskey or brandy will be found very useful.

In a faint, as the brain is commonly deprived temporarily of its proper supply of blood, the individual should be placed on the back and the clothing loosened; in some cases it is well to raise the body and limbs a little above the level of the head.

Sprinkling cold water on the face, ammonia to the nostrils, and warmth to the extremities and over the stomach will also assist in bringing about reaction from a faint.

In convulsions which are usually epileptic, the patient should be prevented from injuring himself.

When clothes are on fire, the wearer should be made to lie down, and should be covered with anything that will exclude the air and smother the flame. Afterward, the burned part must be disturbed as little as possible, and the patient may be enveloped in lint soaked in a mixture of equal parts of linseed-oil and lime-water. Stimulants and anodynes should be administered.

Slight burns are best treated by applying a cloth soaked in a strong solution of baking soda—the bicarbonate of soda. Linseed-oil and lime-water is a good application for such burns.

Sprains must be treated by rest and heat or cold, as is best suited to each case. Sprains of the finger or wrist usually require cold and moist applications. A lotion of lead-water and laudanum is useful to allay inflammation. To promote absorption of any inflammatory products that may be left, painting over the joint with tincture of iodine and rubbing and kneading are useful.

When foreign bodies get into the eye, a good plan is to hold a knitting-needle, or thin lead-pencil, over the upper lid while the person looks, or turns his eyes downward; then seize the lashes of that lid by the fingers of the disengaged hand, and gently turn the lid upward and backward over the needle or pencil. Usually the intruder can be seen and removed. Should the foreign body be imbedded in the eyeball or the eyelid, the case should be left to a surgeon.

A good eyewash is made by dissolving eight grains of borax in a mixture of one-half ounce of infusion of sassafras and one ounce and a half of camphor water.

Never draw a handkerchief, or anything else, between the eyelids to remove a foreign body.

When insects get into the ear, the best way of getting them out is to fill the cavity of the ear with sweet-oil or glycerine. It drowns the animal by closing up its breathing pores, and in a short time it floats to the surface of the fluid used.

When foreign bodies get lodged in the throat, they may sometimes be removed with the fingers or with forceps.

If a piece of food is caught in the windpipe, owing to the epiglottis not shutting down quickly enough, it will usually be coughed out. Tickling the ear with a feather, or slapping the back with the hand, will sometimes excite coughing. If, however, it remains, an effort should be made to remove it with the fingers, and a physician should be called at once.

If a foreign body, such as a pebble or grain of coffee, gets into a nostril, the first thing to do is to try to expel it by gently blowing the nose. If ordinary blowing does not succeed, the child should be made to take a full breath, then closing the other nostril and the mouth, when the lungs empty themselves by expiration, the foreign body may be driven out of the nostril.

Bleeding from the nose can usually be stopped by application of cold water or ice to the outside and inside of the nostrils; but sometimes the bleeding is profuse and obstinate. Vinegar, or a strong solution of alum in warm water, can be snuffed up the nose; or cotton soaked in vinegar or alum-water may be used as a plug.

The bleeding may frequently be stopped by pressing the finger with moderate firmness over the upper portion of the upper lip to the outer side of the nostril from which the blood proceeds. A small, hard roll of paper passed well up beneath the upper lip, in the same situation, is often sufficient. Water as hot as can be borne, carried into the bleeding nostril by gentle efforts at inspiration while the mouth and opposite nostril are closed, in many cases is promptly effectual. Do not blow the nose during or soon after bleeding. Keep the mouth shut and breathe through the nose.

Capillary hemorrhage follows every cut. It usually stops of itself. If it does not, cold water, ice, or vinegar may be applied. For oozing from a large raw surface, a towel may be folded, dipped in water as

hot as the hand can bear, lightly squeezed, so as not to drip, and laid upon the bleeding surface.

Bleeding from the veins is also generally slow and steady The application of cold and continuous pressure upon and below the wound are the proper methods of treatment.

Hemorrhage from the arteries is very dangerous. The blood is bright red, and spurts in a stream or leaps in jets from the divided vessel.

For wounds of arteries of the hand, raising the hand above the head, and making firm pressure with the thumbs just above and in front of the wrist, will usually stop the bleeding. If this fails, and for wounds below the elbow, first grasp the upper part of the arm with both hands and squeeze as hard as possible; then let some one make a thick, hard knot, as big as an egg, in the middle of a handkerchief; place it over the middle of the front of the arm, immediately above the elbow; tie the ends tight at the back, and bend the forearm up so as to press hard against the knot.

For wounds in the upper arm, a knot as big as a fist may be made in any piece of cloth, and shoved hard up into the armpit, and the elbow then brought straight down and held firmly against the side of the chest.

The principal object in arterial bleeding is to obstruct the blood-vessel above the cut, and this can be effected by a knot placed, in the several cases, in front of the bend of the elbow, in the armpit; or, for the lower extremity, behind the bend of the knee, or just below the groin, against which the nearest part of the limb is to be firmly pressed.

When a poison has been swallowed, it is a good plan to empty the stomach as speedily as possible. Vomiting can be effected by several methods. Simple warm water, given cup after cup, is often all that will be necessary. A tablespoonful of ground mustard or of common salt can be mixed with a large tumblerful of water, and this can be given and repeated several times until vomiting is produced. After vomiting has commenced, warm water, flaxseed tea, or gum-arabic water may be given to continue the vomiting and soothe the stomach.

Fats, oils, milk, raw eggs beaten up—all in moderate quantities—are especially valuable when the poison has been of an irritant character. If the sufferer is much depressed by cold, some stimulant, as hot tea, hot coffee, brandy, whiskey, or wine, may be administered. Warmth should also be applied.

Poisons can be arranged into different classes: some are acids, some are alkalies; some are irritant special mineral poisons, such as arsenic, sugar of lead, corrosive sublimate, tartar emetic, phosphorus, lunar caustic; and some are special vegetable poisons, such as strychnia, opium, aconite, Jamestown weed, hemlock, nightshade, toadstool, tobacco, etc., etc. Certain general principles of treatment apply for all the poisons of each special class.

Questions for Review.

How often should the whole body be washed?

What is the least that one can do with any attention to cleanliness or health?

Describe the best process for a thorough wash of the hands.

How often should a hot bath be taken?

What is said about the use of a flesh-brush or rough towel?

When should the teeth be brushed?

How should the hair be combed and brushed at night?

When should the mouth be rinsed out?

Should tooth-brushes be soft or hard? Why?

What is said about pomade?

What is said about oiling the hair?

How may sweet-oil be of service to the body?

Should hot fluids be drunk?

How should sweets, tarts, pastry, confectionery, and sugar be used?

What should be done to the clothes before going to bed?

What should be done to the bed and bedroom in the morning?

What should always be done before sitting down to breakfast?

When and how should those sick with fever, or any infectious disease, be visited?

What precaution should be taken to avoid infection or any low fever?

Mention some good disinfectants and the methods of using them.

How should cold feet at night be treated?

Why should hot and heavy suppers be avoided?

What does going to bed with an entirely empty stomach often cause?

Mention some good rules of hygiene for those troubled with sleeplessness.

To what is the word asphyxia now commonly applied?

What is the derivation of the word?

In asphyxia, what happens to the tidal air?

Mention some of the ways in which asphyxia is produced.

How may death be prevented in cases of asphyxia?

Describe what should be done in apparent drowning.

Name some of the noxious gases which may produce asphyxia.

What is the treatment for asphyxia or suffocation from noxious gases?

How may risk of poisoning from noxious gases be obviated?

What two conditions may be produced by intense heat?

By what is sunstroke decidedly favored?

What are the symptoms of heatstroke or sunstroke?

What treatment should be adopted for a person attacked with sunstroke?

How should a case of heat-exhaustion be treated?

Is an attack of fainting ordinarily dangerous to life?

Describe a faint.

What happens to the brain in a faint?

What should be done to the individual in a faint?

What movements should be controlled in a case of convulsions?

What are the suggestions with reference to the treatment of a convulsion?

When clothes are on fire, what should the wearer do?

Afterward, how should the burned part be treated?

What should be given internally?

How are slight burns best treated?

What is the condition in a sprain?

Where do sprains most frequently occur?

By what is the injury followed?

How should sprains be treated?

What is a good plan for removing foreign bodies from beneath the eyelids?

What advice is given when the foreign body is imbedded in the eyeball or eyelid?

What should be done for the irritation remaining after the removal of a foreign body?

How can a good eye-wash be made?

Should a handkerchief ever be drawn between the eyelids to remove a foreign body?

What is the best method of getting an insect out of the ear?

Mention some of the methods of removing foreign bodies from the throat.

Mention some of the methods of removing foreign bodies from the nose.

How can bleeding from the nose usually be stopped?

If the bleeding is profuse and obstinate, how may it be stopped?

What sort of hemorrhage follows every cut?

If capillary hemorrhage does not stop of itself, how may it be controlled?

How can bleeding from the veins be controlled?

What is the most dangerous form of hemorrhage?

How can bleeding from wounds of the arteries of the hand usually be stopped?

Give the methods of controlling arterial hemorrhage from wounds below the elbow.

Give the methods for wounds in the upper arm, and for wounds in the lower extremities.

What are antidotes?

When a poison has been swallowed, what should be done at once?

How can vomiting be effected?

After vomiting has commenced, what should be given?

What are especially valuable when the poison has been of an irritant character?

What should be done if the sufferer is much depressed or cold?

Name some of the classes into which poisons can be arranged.

What is the proper treatment for the strong mineral acid poisons?

What is the treatment for oxalic acid poisoning?

How will strong carbolic acid act on the skin?

How should a burn produced by it be treated?

What is a good antidote for carbolic acid?

Give the entire plan of treatment in poisoning by carbolic acid.

Mention some of the alkaline poisons.

What are the proper antidotes for alkaline poisons?

Describe the method of making an antidote for arsenic.

What should be done besides administering an antidote?

What is the name of a common arsenical preparation?

For poisoning by sugar of lead, what should be done?

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Give the treatment for corrosive sublimate poisoning.

Give the treatment for tartar emetic poisoning.

How are children sometimes poisoned by phosphorus?

How should such cases be treated?

What is the antidote for lunar caustic?

How do vessels of copper often give rise to poisoning?

For poisoning with copper, what should be given?

What is the treatment for poisoning by nux vomica, or strychnia?

What are some of the preparations of opium?

What symptoms are caused by opium preparations when taken in poisonous amounts?

What is the treatment for opium poisoning?

What symptoms are produced by poisonous doses of aconite, hemlock, deadly nightshade, the Jamestown weed, monk's-hood, toadstools, and tobacco?

How should persons poisoned by these substances be treated?

THE END.